Large-Scale Marine Development Projects (Mineral, Oil and Gas, Infrastructure) Proposed for Canada's North

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TABLE OF CONTENTS

LIST OF TABLES iv
LIST OF FIGURES v
LIST OF APPENDICES vi
ABSTRACT AND RÉSUMÉ viii
INTRODUCTION 1
MATERIALS & METHODS 2
CANADIAN ARCTIC SHIPPING 5
OVERALL DEVELOPMENT 9
Mineral resource development 11
Oil and gas development 14
Infrastructure 21
LABRADOR 22
Mineral resource development 22
Oil and gas development: offshore Labrador 26
QUÉBEC 28
Mineral resource development 28
NUNAVUT 35
Mineral resource development 35
ONTARIO 45
Mineral resource development 45
MANITOBA 45
Mineral resource development 45
NORTHWEST TERRITORIES 46
Mineral resource development 46
Oil and gas development: Mackenzie Delta/Beaufort Sea 46
YUKON 54
Mineral resource development 54
EASTERN ARCTIC OFFSHORE 55
Oil and gas development 55
HIGH ARCTIC OFFSHORE 57
Oil and gas development 58
INFRASTRUCTURE 59
CONCLUSION 62
REFERENCES 63
APPENDICES 74

LIST OF TABLES

Table 1. Process and associated time frame to bring a mine into production.....4

Table 2. Stage and estimated time schedule for a generalized offshore oil and gas development project.....4

Table 3. Characteristics of the major mineral development projects with a marine transportation component that are currently in production or in advanced development stage in Canada's North.....13

Table 4. Summary of offshore oil and gas exploration research activities currently underway or proposed in the Canadian Arctic.....17

Table 5. Summary of offshore oil and gas exploration and development operations currently underway or proposed in the Canadian Arctic.....19

Table 6. Summary of major infrastructure projects in Canada's North planned from 2013 until 2018.....21

Table 7. Mine projects in Labrador under exploration, development, or production that have, or will potentially have a marine transportation component.....24

Table 8. Multi-year seismic programs active and proposed for offshore Labrador 2010–2017.....26

Table 9. Mine projects in northern Québec under exploration, development, or production that have, or will potentially have a marine transportation component.....30

Table 10. Mine projects in Nunavut under exploration, development or production, that have or will potentially have a marine transportation component.....37

Table 11. Potential offshore oil and gas exploration and development activities in the Mackenzie Delta/Beaufort Sea region from 2013 to 2027 (Callow 2013).....51

Table 12. Current oil and gas exploration, significant discovery and production licences in the Beaufort Sea and Mackenzie Delta, to be used in conjunction with Figure 15 (AANDC 2012c).....51

LIST OF FIGURES

Figure 1. Canada's Marine Ecoregions (DFO 2009). 3

Figure 2. Network of major vessel routes through the Canadian Arctic in 2004, which has largely remained stable since then (Arctic Council 2009) 7

Figure 3. Major international shipping routes through the Canadian Arctic that are expected to see an increase in vessel traffic (The Mariport Group Ltd. 2007). 8

Figure 4. Summary of development projects (oil and gas, mine, and infrastructure) planned for Canada's North from 2013 to 2020 according to starting date of operations. 9

Figure 5. Summary of development projects with a marine component (infrastructure or shipping) in Canada's North 10

Figure 6. Overall tonnage (Mt: millions of tonnes) of mined ore (blue bars) and the estimated number of shipments (red line; based on a 180,000 dead-weight tonne vessel) passing through Canadian Arctic waters from 2005 to 2020.. 12

Figure 7. Mineral development projects in Canada's North shown as tonnage per year at most probable marine ports of export.. 14

Figure 8. Canada's seven hydrocarbon regions and the percentage of conventional hydrocarbon reserves they are estimated to hold (Canadian Centre for Energy Information 2007) 18

Figure 9. Major mineral projects in Labrador (undergoing exploration, development, or production) that have or will likely have a marine transportation component 25

Figure 10. Significant discovery licences (pink) and exploration licence areas (green) in the Labrador offshore region (C-NLOPB 2013) 27

Figure 11. Major mineral projects in northern Québec under exploration, development, or production that have or will potentially have a marine transportation component 34

Figure 12. Major mineral projects in Nunavut under exploration, development, or production that have or will potentially have a marine transportation component 42

Figure 13. (Inset 1 from Fig. 12) Major mineral projects in Nunavut under exploration, development, or production that have or will potentially have a marine transportation component 43

Figure 14. (Inset 2 from Fig. 12) Major mineral projects in Nunavut under exploration, development, or production that have or will potentially have a marine transportation component 44

Figure 15. Beaufort Sea and Mackenzie Delta oil and gas dispositions as of November 2013 50

Figure 16. Eastern Arctic offshore oil and gas dispositions 56

Figure 17. Arctic Islands (Sverdrup Basin) oil and gas dispositions 58

Figure 18. Arctic Fibre's proposed fibre optic telecommunications system, demonstrating the primary backbone of the network divided into five route segments (Arctic Fibre 2013) 61

LIST OF APPENDICES

Appendix 1. Representative persons in provincial, territorial or federal governments of Canada, or review boards, who were contacted to validate the information related to resource development projects in this report 74

Appendix 2. Overview of a mine life cycle, illustrated in four general phases (Environment Canada 2013) 78

Appendix 3. Shipping Safety Control Zones in the Canadian Arctic and dates of entry by vessels of different categories (Transport Canada 2012) 79

Appendix 4. References for mineral resource development projects, oil and gas exploration and development research projects, and oil and gas exploration and development operations. 81

Gavrilchuk, K., and Lesage, V. 2014. Large-scale marine development projects (mineral, oil and gas, infrastructure) proposed for Canada's North. Can. Tech. Rep. Fish. Aquat. Sci. 3069: viii + 84 pp.

ABSTRACT

The number of natural resource development projects in Canada's North has increased substantially in recent years, and this trend is expected to continue or accelerate in the future. Several of these development projects have or are expected to have a marine component that involves marine shipping, infrastructures, or both. In this report, we summarize the available information on current, developing, and planned large-scale resource development projects (mineral, oil and gas, infrastructure) in Canada's North with the objective of using the current profile of projects as a planning guide for related studies, and for determining where baseline data for marine wildlife and habitat might be needed for assessing potential effects of these projects. The majority of mineral development projects currently planned to enter production between now and 2020 are located in Labrador (n=4), Québec (n=6), and Nunavut (n=8). Over the same period, oil and gas exploration activity is planned to be concentrated in the Labrador Sea, the Beaufort Sea, and the Mackenzie Delta. Seven major infrastructure projects, not directly related to natural resource exploitation, are planned to be operational by 2020.

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RÉSUMÉ

Le nombre de projet d'exploitation des ressources naturelles dans les régions nordiques du Canada a augmenté de manière substantielle récemment, et cette tendance devrait se poursuivre ou s'accentuer dans le futur. Plusieurs de ces projets de développement comportent ou devraient comporter une composante marine qui implique du transport, des infrastructures ou les deux. Dans ce rapport, nous présentons un sommaire des informations disponibles concernant les grands projets de développement (mines, gaz et pétrole, infrastructure) dans le nord Canadien, dans l'optique d'identifier les régions soumises à ce développement, et où l'acquisition de données de base relativement à la faune marine et leur habitat peut être nécessaire afin d'évaluer les effets possible de ces projets. La majorité des projets miniers qui entreront en production d'ici 2020 se situent au Labrador (n=4), au Québec (n=6) et au Nunavut (n=8). Au cours de la même période, les activités d'exploration gazière et pétrolière seront concentrées dans la mer du Labrador, la mer de Beaufort et le Delta du Mackenzie. Sept projets majeurs d'infrastructure, qui ne sont pas directement liés à l'exploitation des ressources naturelles, devraient être opérationnels d'ici 2020.

INTRODUCTION

Natural resources are a key economic driver for Canada and the global demand for commodities is steadily increasing. As such, the geopolitical significance of the Arctic, a region which holds a large and diverse natural resource endowment, is also rising (Energy and Mines Ministers Conference 2013). In 2007, the Government of Canada launched a long-term *Northern Strategy* program in order to exercise Northern sovereignty and jurisdiction, promote economic and social development, protect environmental heritage, and devolve Northern governance (Government of Canada 2009a). The government has also launched initiatives that will stimulate resource development in Canada's North, such as the establishment of the Canadian Northern Economic Development Agency (CanNor) in 2009, which includes the Northern Projects Management Office (NPMO), as well as the investment of $100 million over seven years (2013-2020) for the Geo-mapping for Energy and Minerals (GEM) program in the North (Natural Resources Canada 2008). The GEM program was designed to advance geological knowledge in the North, support further exploration of natural resources, and guide decisions on land use. Thus, there is a strong movement by federal and provincial governments, as well as industry to explore and define energy and mineral reserves in the Arctic. The extent of development foreseen within Canada's North will have considerable commercial, social, and environmental implications.

The number of resource development projects in Canada's North has increased substantially in recent years, and plans indicate this trend is expected to continue or accelerate in the future. Several of these development projects have or are expected to have a marine component that involves marine shipping, infrastructures, or both. Fisheries and Oceans Canada is seeking to identify marine regions in Canada's North where development activities may converge, and where acquisition of baseline data on marine organisms (e.g. distribution, local density, population size or biomass, habitat requirements, potential threats, etc.) will be necessary to ensure ecologically responsible resource development.

The objective of this document is to summarize current information from federal, territorial, and provincial departments, agencies, review boards, and private sectors on large-scale resource development projects (mineral, offshore oil and gas, offshore energy, infrastructure) in Canada's North, including Labrador, that are currently operational, in development, or in exploratory phase. The pattern of planned development in this summary can be used to inform studies and deployment of research efforts.

MATERIALS AND METHODS

This document was prepared based on information available at the time of writing (i.e. May 2013, unless otherwise indicated). Information on mineral land tenure and oil and gas dispositions in the Canadian Arctic was retrieved from provincial and federal government websites and from annual reports. Details related to mineral development and oil and gas projects were derived from company news releases, websites, and technical reports filed with SEDAR (System for Electronic Document Analysis and Retrieval, a mandatory document filing and retrieval system for all Canadian public companies; www.sedar.com), which are all available publicly. Development projects listed in this report, including associated information, were validated by representative persons in each provincial, territorial or federal government (Appendix 1).

Development projects that involved a marine transportation component in northern regions of the following seven provinces and territories were examined: Labrador, Québec, Ontario, Manitoba, Northwest Territories, Yukon, and Nunavut. Only offshore oil and gas development was evaluated for the purpose of this document as terrestrial oil and gas activities in northern Canada do not export via northern routes (there is one exception for which a decision has not yet been taken involving exporting bitumen/heavy oil from the Prairie Provinces to the Port of Churchill in Manitoba; to be discussed further in this report). Resource development projects occurring in Saskatchewan, Alberta, and British Columbia do not use marine areas of concern described in this report and were therefore not considered. Mining projects that are located in northern regions of Canada but with no plans to export ore to northern ports were not included. However, with the potential development of new transportation infrastructure in the North, these mines may eventually shift shipping routes.

Mineral and oil and gas projects were entered into one of three status categories: exploration, development, or production (Tables 1 and 2). Understanding the general time period required to bring a mine or oil/gas field into production helps to forecast the number of exploitation projects likely to enter production at a given time. While a project may move into development or production phase, exploration for additional prospects around the main site tends to be ongoing. The process of developing a mineral deposit requires completing a series of steps (see flowchart in Appendix 2). As steps are completed, there is a progressively increasing likelihood that the mineral prospect will be developed into a mine. The initial stage in developing a mine deposit is exploration and discovery. If a significant mineralization is found, the next stage involves advanced exploration to define an economic resource. Following positive results, the project will progress towards preliminary economic studies and feasibility studies to establish a mine plan and associated financial strategy. Finally, projects must successfully meet all conditions of the environmental impact assessment process (consult the Canadian Environmental Assessment Agency for more information; www.ceaa-acee.gc.ca). The timeline associated with environmental impact assessments for these types of projects may take two or more years, and often involve at least two to three years of data collection prior to submission of the project's Environmental Impact Assessment (Canadian Environmental Assessment Agency 2013). The construction phase varies depending on the scale of the project, and can last from two to four years (Government of Canada 2013).

Any information pertaining to the port of export, the maritime transport route, the number of vessel transits per annum, or any other marine activity was recorded when available. In cases where the number of annual vessel transits was not provided for mineral development projects, tonnage per year was used to estimate the annual number of shipments required. However, this is an approximation as the size of the vessel used will directly influence the number of annual shipments.

For illustration purposes, projects were mapped relative to the following Marine Ecoregions of Canada, as defined by Fisheries and Oceans Canada: Labrador Shelf, Eastern and Western Arctic, Hudson Bay Complex, Arctic Archipelago, and Arctic Basin (DFO 2009; Fig. 1).

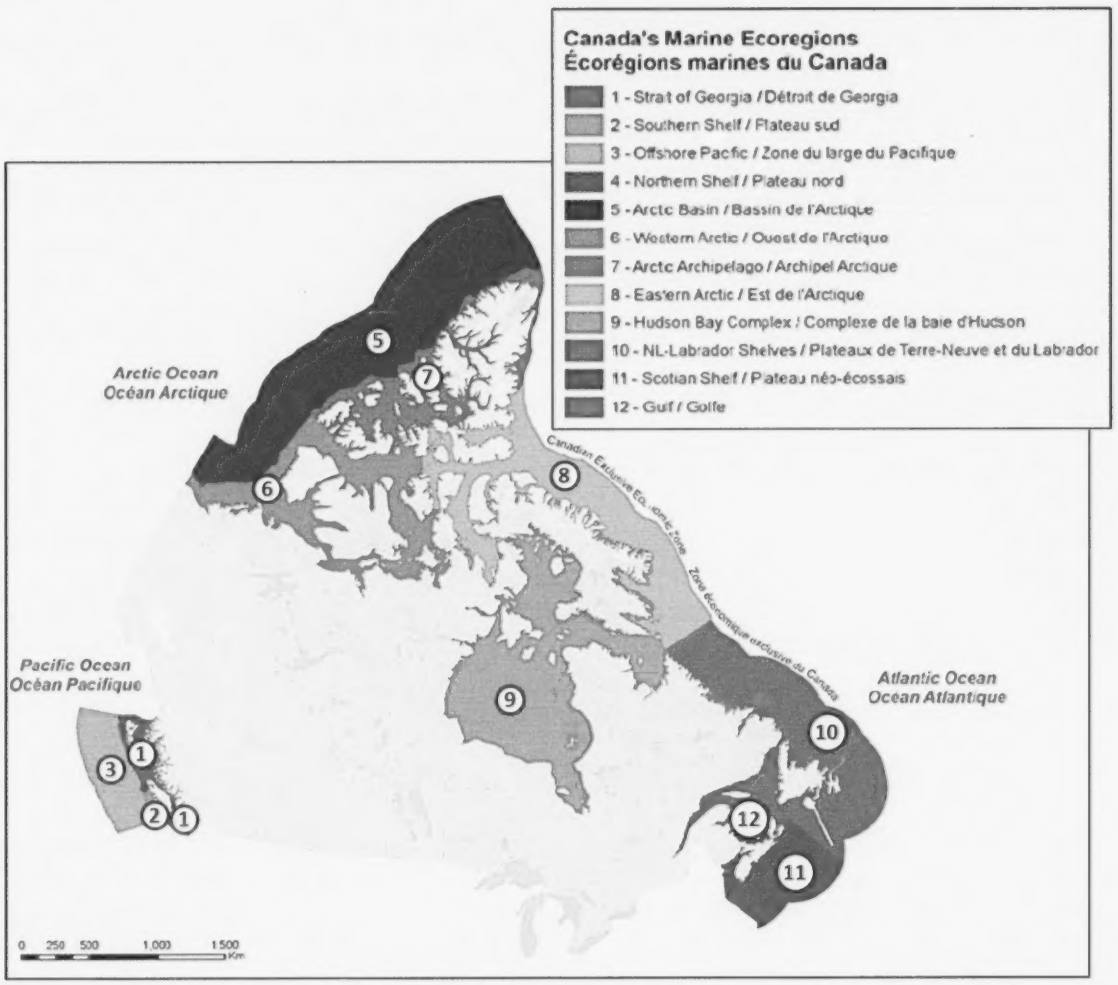

Canada's Marine Ecoregions
Écorégions marines du Canada
1 - Strait of Georgia / Détroit de Georgia
2 - Southern Shelf / Plateau sud
3 - Offshore Pacific / Zone du large du Pacifique
4 - Northern Shelf / Plateau nord
5 - Arctic Basin / Bassin de l'Arctique
6 - Western Arctic / Ouest de l'Arctique
7 - Arctic Archipelago / Archipel Arctique
8 - Eastern Arctic / Est de l'Arctique
9 - Hudson Bay Complex / Complexe de la baie d'Hudson
10 - NL-Labrador Shelves / Plateaux de Terre-Neuve et du Labrador
11 - Scotian Shelf / Plateau néo-écossais
12 - Gulf / Golfe
Arctic Ocean
Océan Arctique
Pacific Ocean
Océan Pacifique
Atlantic Ocean
Ocean Atlantique
0 250 500 1,000 1,500
Km

Figure 1. Canada's Marine Ecoregions (DFO 2009). The six Arctic regions considered in this report were the Arctic Basin (5: dark blue), Western Arctic (6: light blue), Arctic Archipelago (7: red), Eastern Arctic (8: tan), Hudson Bay Complex (9: green), and the Labrador Shelf (10: purple).

Table 1. Process and associated time frame to bring a mine into production. The exploration phase can be further subdivided into early (E) and advanced (A) exploration. Companies will often work on multiple stages simultaneously to optimize the time to production in a cost-effective manner.

Stage	Description	Estimated time period (yr)
Exploration	• Prospecting, mapping, surveying (E) • Exploratory drilling (E) • Bulk sampling (A) • Mineral Resource Estimate (A)	3–5
Development	• Preliminary Economic Assessment • Prefeasibility Study • Feasibility Study • Environmental Impact Assessment • Construction	5–15
Production	• Mining and transport to processing facility or market	Depends on quantity and quality of reserve and whether mining is still profitable

Table 2. Stage and estimated time schedule for a generalized offshore oil and gas development project. Estimated time period will vary with the location of the offshore development. For example, a major impediment to projects located in Arctic waters or far from the mainland is the lack of transportation infrastructure to markets.

Stage	Description	Estimated time period (yr)
Exploration	• Geophysical surveying • Exploratory drilling	up to 9
Development	• Well drilling • Feasability and economic analyses • Environmental and socioeconomic assessments	5–10
Production	• Extraction and transport to refinery or market	25 (renewable if still producing)

CANADIAN ARCTIC SHIPPING

The regulation of shipping in the Arctic is complicated by the global nature of shipping and the desire of several countries to designate polar marine straits as international waters (Carnaghan and Goody 2006). Transport Canada, a federal entity, regulates, inspects, and enforces vessel, equipment, and crew procedures under the *Canada Shipping Act* as well as related acts and codes. Under the *Oceans Act*, the Canadian Coast Guard, a branch of Fisheries and Oceans Canada, provides navigational aids for commercial and recreational vessels, enforces many regulations on the water, and delivers icebreaking services. The Canadian Hydrographic Service, also under the *Oceans Act,* is responsible for "measuring and describing the physical features of Canada's navigable waters and their marginal land areas and making this information available in the most suitable form for use by navigators." Environment Canada provides the Canadian Ice Service (CIS), which contains accurate and timely information on ice in Canada's navigable waters.

The marine environment in northern Canada includes the Arctic Ocean, Beaufort Sea, Hudson Bay, Foxe Basin, Baffin Bay, and several channels and straits between the islands of the Arctic Archipelago as well as the Labrador Sea. Climate change will result in both challenges and opportunities for these marine regions. With decreasing sea ice extent and/or duration, the opening of new shipping channels will result in opportunities for increased supply of cargo to growing Arctic communities, facilitate transport of natural resources from the North to southern and foreign markets, and reduce transit times between the Atlantic and Pacific oceans (The Mariport Group Ltd. 2007, Lemmen et al. 2008).

Current shipping routes in the Canadian Arctic have largely remained unchanged since 2004 (D. Avey, Transport Canada, pers. comm.; Fig. 2) and can thus provide a baseline shipping guide when projecting future activity under various scenarios of population and economic growth (Arctic Council 2009). Sea-ice duration in the Canadian Arctic is predicted to be 10 days shorter by 2020, 15 to 20 days shorter by 2050, and 20 to 30 days shorter by 2080, which will likely result in an extended shipping season (Loeng et al. 2005). Transport Canada has divided the Canadian Arctic into Marine Safety Control Zones based on their degree of navigability and periods of the year when different vessels are permitted to enter (Appendix 3). The number of shipping transits in the Canadian Arctic has already increased substantially from 158 transits in 2009 to 270 in 2010. The number of ships navigating through the Northwest Passage grew from seven in 2009 to 18 in 2010 and 27 in 2011 (Ruffilli 2011). Several projects in the coming decade are anticipated to significantly alter northern Canada's marine transportation system (Arctic Council 2009). The following two transportation routes in the North are predicted to see an increasing number of vessel transits over the coming years:

> *1) The Arctic Bridge Gateway*. Canada's only major international Arctic seaport, Churchill, MB, is at one end of an international Arctic shipping route connecting to the Port of Murmansk, Russia. This Arctic Bridge Gateway offers the opportunity to shorten shipping routes, open new trade avenues for Manitoba and Canada with international partners, reaffirm Canada's sovereignty position in the Arctic, and integrate northern Manitoba into the world trade framework. The Churchill Gateway

Development Corporation, which is a public–private partnership of Manitoba, and OmniTRAX, a transportation leader in North America, are working to build diversified two-way traffic through the port of Churchill. Plans are to promote future shipments and expand the types of commodities shipped into and out of Churchill over the Arctic Bridge Gateway to ensure that the port can be viable, competitive, and self-sustainable in the long-term (Canada's Arctic Gateway 2010). For instance, oil producers mainly in Alberta are considering transport of commodities from Churchill an increasingly likely export hub. However, certain challenges would need to be overcome, such as the shorter shipping season using this route (July to mid-October). The shipping season could be extended with the use icebreakers to accompany tankers; however, this would considerably increase transport costs (Arnason 2013).

2) The Northwest Passage. The Atlantic and Pacific oceans are connected by the Northwest Passage, which extends from Baffin Bay through Lancaster Sound to the Beaufort Sea and has five navigable routes or passages, with variations, through the Arctic Archipelago (see Arctic Council 2009 for a description of these routes; Fig. 3). An ice-free Northwest Passage could generate a significant economic benefit for shipping companies, as it would provide a marine travel route approximately 7000 km shorter between Japan and England than the Panama Canal. However, considerable debate has emerged recently regarding future vessel traffic in the Northwest Passage, mainly due to the difficulty in accurately projecting near-future reductions in sea-ice cover (Prowse et al. 2009). Nonetheless, by mid-century (2040–2059), September sea-ice conditions are predicted to open up trans-Arctic shipping through the Canadian Arctic. For instance, the probability for open-water vessels to cross an ice-free Northwest Passage is forecast to increase from 17–27% in 2006–2015 to 53–60% by 2040–2059 (Smith and Stephenson 2013).

The Arctic Marine Shipping Assessment (AMSA), a research initiative co-led by Canada, Finland, and the United States, is the product of a multi-year Arctic Council effort that assessed vessels and their uses within the Arctic Ocean, their potential impacts on humans and the Arctic marine environment, and their associated marine infrastructure requirements. Outcomes of the AMSA were released for the first time in 2009 (Arctic Council 2009), subsequently updated in 2011 (Arctic Council 2011), and recently amended during the second biennial effort in 2013 (Arctic Council 2013). The resulting reports include key findings and recommendations to establish a strategic framework for future action on improving marine safety, protecting the marine environment and implementing uniformity of Arctic shipping governance. Available to the public, the ArcticData portal (www.arcticdata.is; accessed 20 February 2013), provides access to a wealth of data collected and integrated in the AMSA. This database is managed by the Conservation of Arctic Flora & Fauna (CAFF) and Protection of the Arctic Marine Environment (PAME) Working Groups of the Arctic Council, and designed as a flexible tool that can be continuously updated with additional information and used to further assess environmental impacts from vessel activity, identify traffic loads on a regional basis, and provide a baseline for analyses of future increased vessel activity in the Arctic.

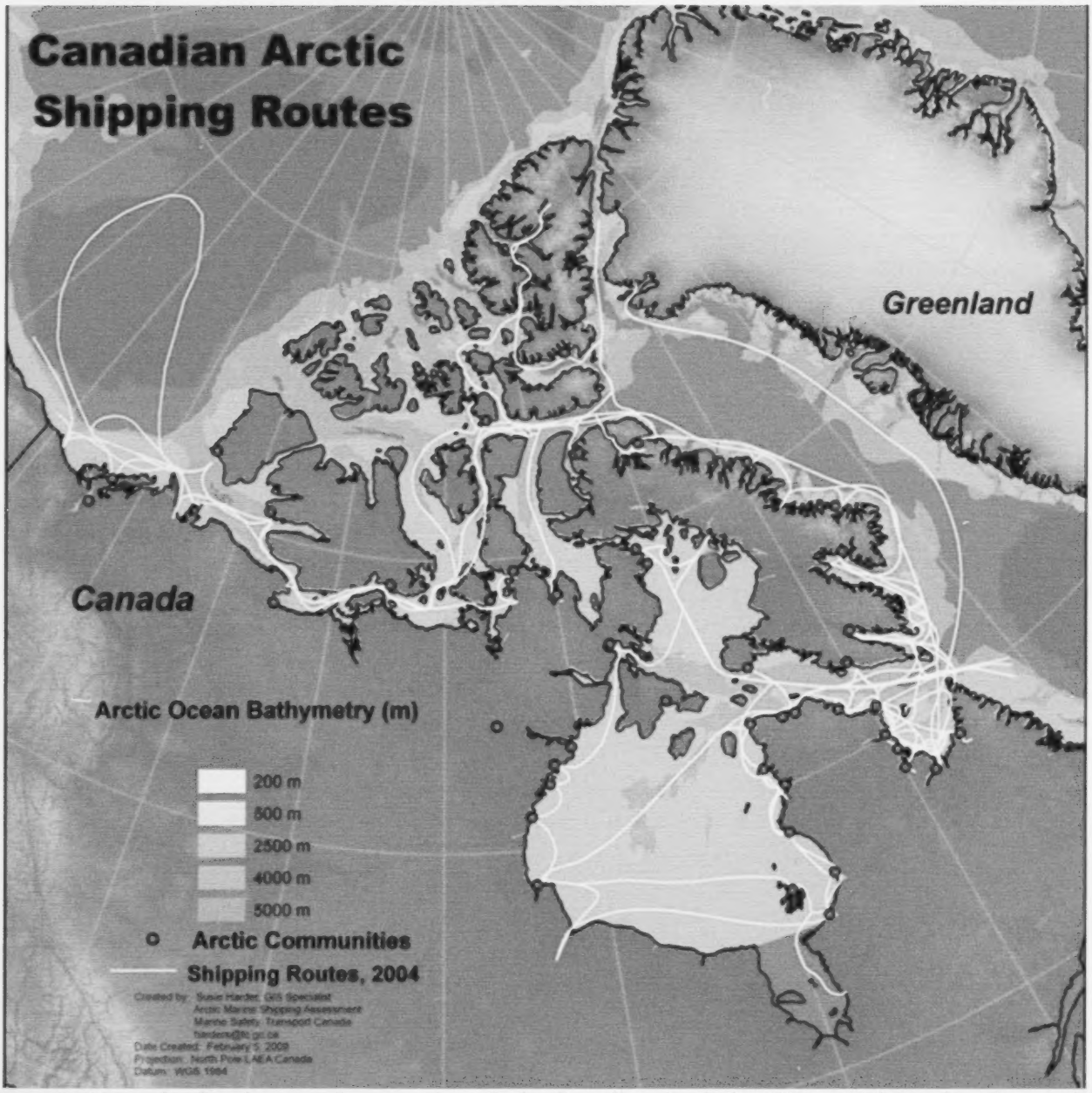


Figure 2. Network of major vessel routes through the Canadian Arctic in 2004, which has largely remained stable since then (fishing routes not included). Most shipping traffic serves to resupply Arctic coastal communities, with between 1 and 10 transits per year. Hudson Strait experiences the greatest level of shipping activity, with 11–20 transits per year. Currently, no shipping route has over 20 trips per year (reproduced with permission from Arctic Council 2009).

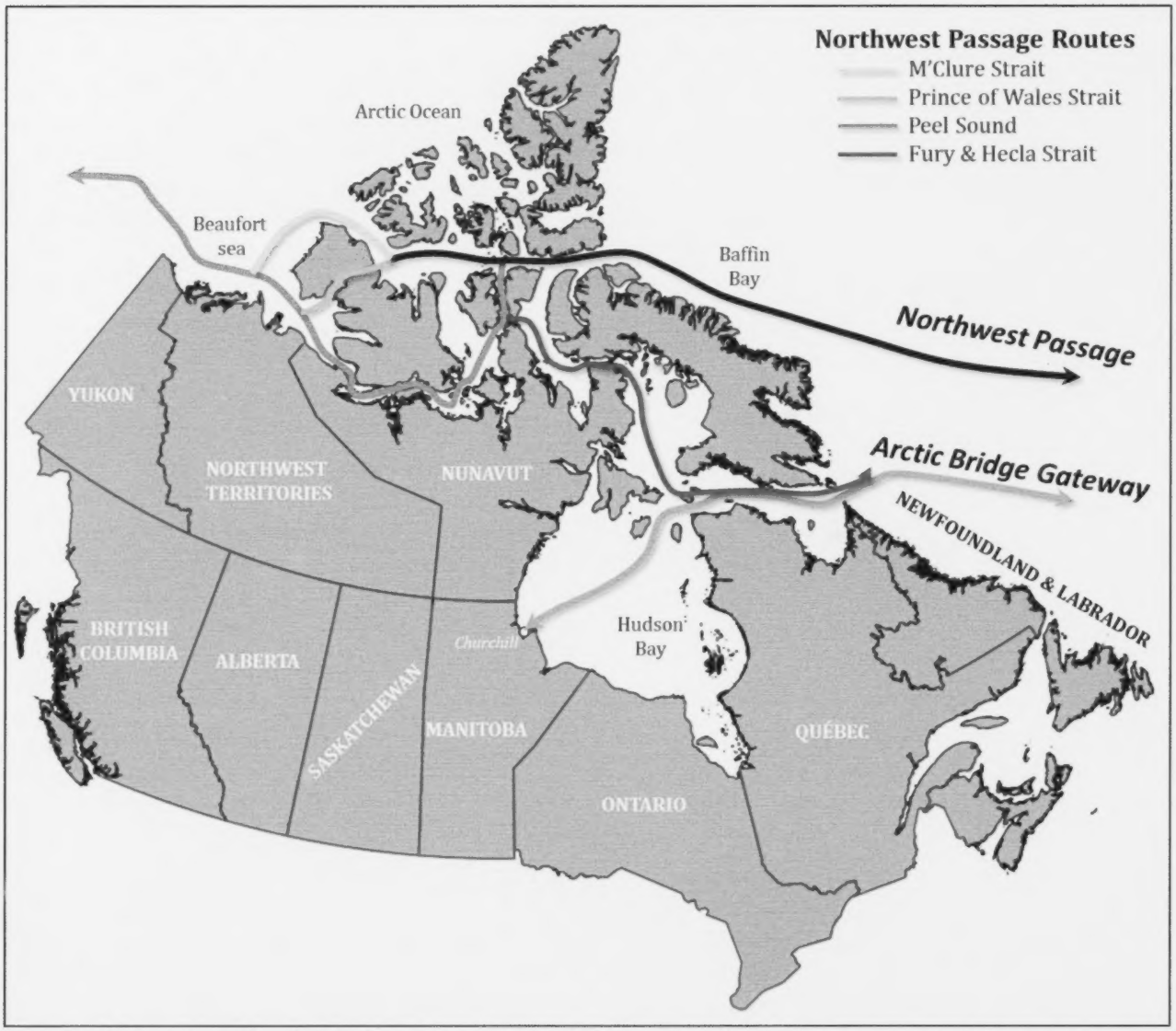


Figure 3. Major international shipping routes through the Canadian Arctic that are expected to see an increase in vessel traffic (The Mariport Group Ltd. 2007): (1) The Northwest Passage, with seven potential routes through the Canadian Archipelago, of which three are considered feasible for routine marine traffic (M'Clure Strait, Prince of Wales Strait, and Peel Sound), and a fourth that is less used (Fury and Hecla Strait); (2) The Arctic Bridge Gateway connects the major seaport in Churchill, MB, to Russia via Hudson Bay, Hudson Strait, and the Labrador Sea. Shipping routes are approximate.

OVERALL DEVELOPMENT

More than 25 development projects with a marine component could be operational by 2020 in Canada's North (Fig. 4). The peak in 2017 corresponds to projects in development phase that are currently at, will soon enter, or have recently completed the environmental impact assessment stage, and to which is associated an additional two- to four-year construction phase. A corollary is that most projects that would enter production after 2017 are still in exploratory phase and lack a formal starting date for the production phase, and could therefore not be compiled. As a result, the number of projects in years 2018 and later is likely an underestimate.

The global mapping of current or planned activities, including projects in exploratory phase, revealed that large development projects are widespread in all regions of Canada's North except the Canadian Arctic Archipelago, although this is not due to a lack of potential for resource development in this region (Fig. 5). While projects related to oil and gas are mainly concentrated off Yukon and the Northwest Territories, mining as well as infrastructure projects are mainly concentrated in Nunavut, Québec, and Labrador.

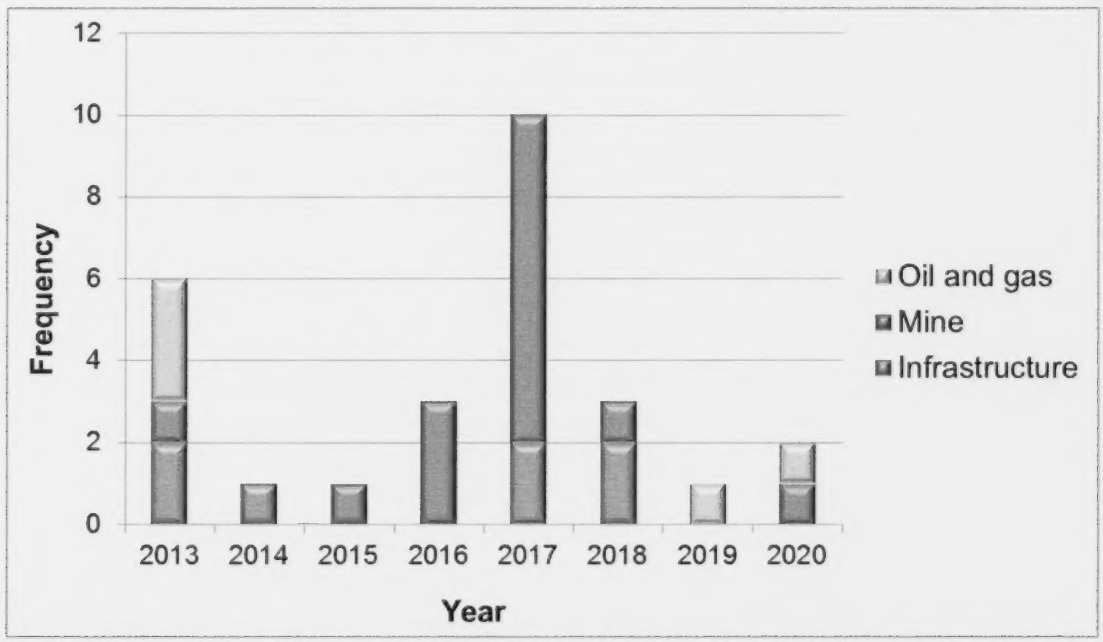


Figure 4. Summary of development projects (oil and gas, mine, and infrastructure) planned for Canada's North from 2013 to 2020 according to starting date of operations. Start dates are tentative and dependent on successful regulatory review processes and economic viability. Forecast is subject to change as new projects move into advanced development stages and starting dates become more precise. See Tables 3, 4, and 5 for project details.

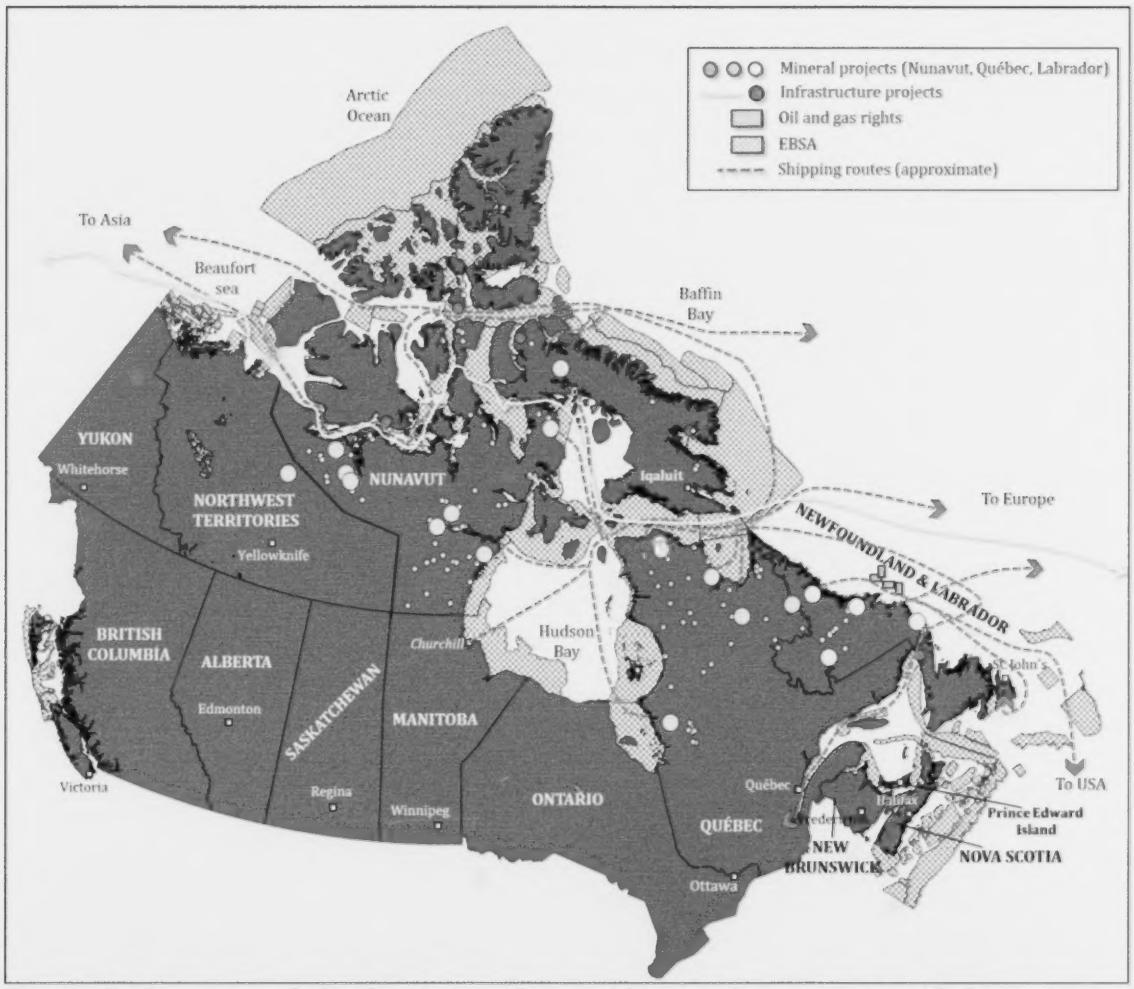


Figure 5. Summary of development projects with a marine component (infrastructure or shipping) in Canada's North. Mineral development projects currently in production or at a late-development stage (large circles) and those at the exploration or early development stage (small circles) are presented for Nunavut (blue circles), Québec (green circles), and Labrador (yellow circles). Region-specific details are presented in Tables 6, 8, and 9. Infrastructure projects (red circles), oil and gas rights (i.e., land leases; orange boxes), and the proposed subsea fibre optic telecommunications cable (the yellow trans-Arctic line) are also presented. Shipping routes as defined by mineral development companies are indicated with red dashed lines and are approximate. Note that some projects have not yet clearly defined their shipping routes, and many are dependent on where markets will be. Ecologically and Biologically Significant Areas (EBSAs) in the Canadian Arctic are shown as purple hatched polygons (DFO 2011).

Mineral resource development

Northern regions of Canada are emerging as important industrial targets due to the large untapped resource potential and the growing demand for natural resources. Expansion of the Canadian mining industry is directly coupled to world markets. Projections have identified the overall demand for natural resource commodities to rise over the long term (Rhéaume and Caron-Vuotari 2013). The Conference Board of Canada forecasts the overall northern metal and non-metallic mineral output to grow by 91% from 2011 to 2020, with a compound annual growth rate of 7.5% (Rhéaume and Caron-Vuotari 2013). The majority of producing mines are already found in the northern extents of Canada's provinces and territories. This is due in part to the country's geological composition (the Canadian Shield is the largest and oldest geological formation and extends from the Northwest Territories east to Labrador). Presently, the lack of infrastructure and the harsh climate represent key challenges to northern mining development (NEB 2009). However, long-term trends in global demand for minerals, primarily driven by economic growth in newly industrialized countries, will encourage new mining projects. The discovery of significant mineral deposits requires a great deal of exploration activity. Put into perspective, it has been estimated to take an average 1,000 exploration projects to locate a deposit of sufficient quality (Cook 2009).

Emerging market nations such as China and India are experiencing progressive industrialization resulting in a demand for commodities required for construction, notably iron ore for steel making (Government of India 2013, China Energy Group 2014). Nuclear energy is expected to increase by around 70% to 2035, led by China, Korea and India, some of the world's largest energy consumers (KPMG International 2012, World Nuclear Association 2013). In February 2012, Canada and China signed an agreement that will allow for increased exports of Canadian uranium to China. This collaboration will enhance Canada's export activities and mutual relations with China (Prime Minister of Canada 2012a). In addition, Canada and India have signed a Nuclear Cooperation Agreement to allow Canada to export and import controlled nuclear materials, equipment and technology to and from India (Prime Minister of Canada 2012b). Global demand for rare earth elements is also rising, partly since China has reduced rare earth element export quotas by nearly 50% since 2011 (Humphries 2013). China's control on the rare earth supply chain, from upstream mining to downstream processing and end-user products, is expected to remain relatively stable over the next three years (Humphries 2013). However, with the increasing number of companies exploring and mining for rare earth elements globally, the construction of new rare earth refineries outside of China will be encouraged (CEC Rare Earth Corp. 2013). The Canadian Rare Earth Elements Network (CREEN), a recently established group of exploration companies, Natural Resources Canada (NRCan), research centres, and other partners, plans to secure 20% of the global rare earth supply market by 2018 (CREEN 2013). Canada is planning to position itself as a major producer of the valued 'heavy' rare earth elements over the 2017 to 2020 time period (Fekete 2014). Heavy rare earth elements (gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium) are used in the manufacturing of new technology, laser equipment, clean energy, aerospace, automotive, defence and a suite of other industrial products (www.reehandbook.com; accessed 13 December 2013).

The following sections include detailed lists of the major mineral projects in exploration, development, or production in Canada's North, which have—or will likely have—a marine component. As the global economy can experience fluctuation closely tied to the demand and prices paid for commodities, this list of projects and associated information is subject to change with time. However, they are presented to serve as a guideline for environmental authorities to identify regions that hold industrial potential. If all mine projects planned between 2013 and 2020 for Canada's North are combined, and if we include mines presently in production, up to 80 million tonnes (Mt) of ore will be shipped through Arctic marine regions with a peak in 2017 (and possibly in years beyond that date, considering the difficulty in forecasting exploitation volume and start dates for projects currently in exploratory phase) (Table 3; Fig. 6). This represents up to 433 shipments per year, based on a vessel capacity of 180,000 dead-weight tonnes (DWT; Fig. 6), and includes five projects shipping from Labrador, another five from Québec, and eight from Nunavut (Table 3; Fig. 7). Note that the peak in 2017 in Fig. 6 corresponds to the seven mines anticipated to enter production based on their current status (e.g., presently undergoing economic/feasibility studies and/or environmental impact assessments). As indicated previously, the overall tonnage per year forecast in Fig. 6 is likely an underestimate as several projects currently in the exploratory or early development phase have not yet set a production date for the proposed mine project.

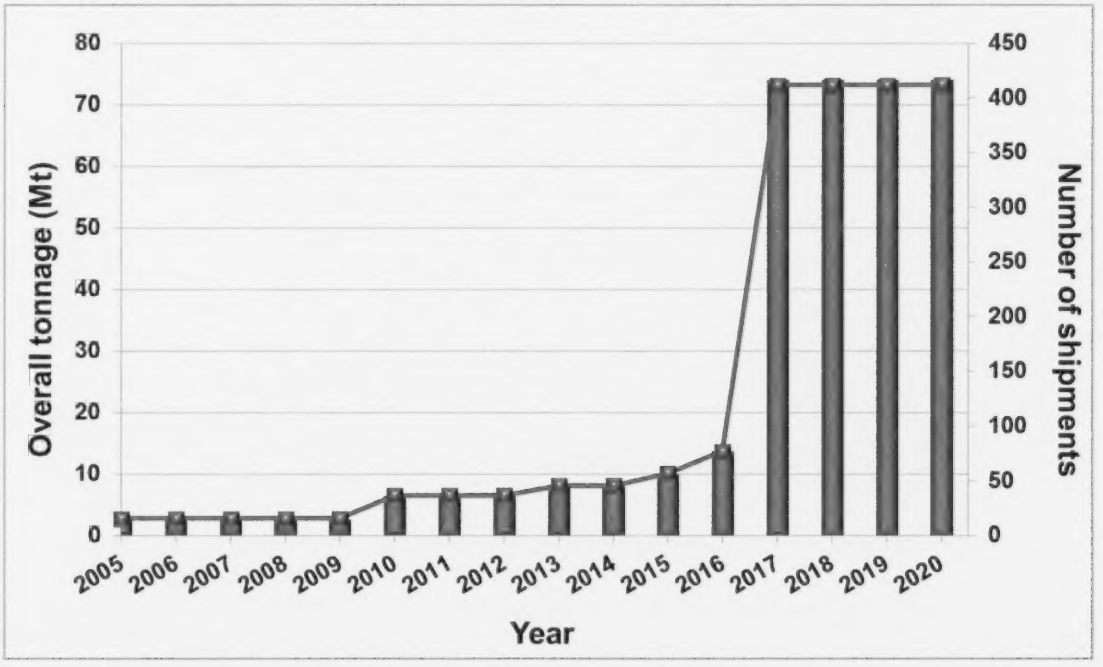


Figure 6. Overall tonnage (Mt: millions of tonnes) of mined ore (blue bars) and the estimated number of shipments (red line; based on a 180,000 dead-weight tonne vessel) passing through Canadian Arctic waters from 2005 to 2020. Tonnage is based on currently producing mines and those expected to enter production between 2013 and 2020 in Labrador, Québec, and Nunavut, and which are expected to use marine transportation for ore export (Table 3). The forecast after 2017 is likely underestimated given the uncertainty associated with start dates of potential development projects.

Table 3. Characteristics of the major mineral development projects with a marine transportation component that are currently in production or in advanced development stage in Canada's North. LOM: life of mine (production start year in parentheses); TPY: tonnage per year in millions of tonnes (Mt; which may fluctuate annually); shipments per year is based on a standard 180,000 DWT vessel and does not include the number of shipments required for mine construction and maintenance (the number of shipments is rounded). The number of shipments per year for projects with lower tonnages per year may be biased downward given that these projects may opt for smaller vessels and thus, a larger number of trips might be required for ore transport. Marine Ecoregions in the Canadian Arctic (Fig. 1) through which shipping will occur (or potentially occur, in parentheses) are indicated. References for each project are presented in Appendix 4).

Province/ territory	Mine	LOM (start yr)	TPY (Mt)	Shipments per year	Marine Ecoregion
Labrador	Voisey's Bay	30 yr (2005)	1.4	9	10
Labrador	Churchill River Project	25 yr (2015)	2	11	10
Labrador	Foxtrot Project[1]	10 yr (2017)	0.004	1	10
Labrador	Michelin Project	18 yr (2018)	0.003	1	10
Québec	Raglan	25 yr (1997)	1.4	7	9, 10
Québec	Nunavik Nickel	13 yr (2013)	1.6	9	9, 10
Québec	Eldor Project	25 yr (2016)	0.02	1	9, 10 (5, 6, 8)
Québec	Hopes Advance Bay	30+ yr (2017)	10-20	56–111	9, 10 (5, 6, 8)
Québec	Duncan Lake	20 yr (2017)	12	67	9 (5, 6, 8, 10)
Québec	Strange Lake	30 yr (2016-17)	0.02	1	10 (5 - 6 - 8)
Nunavut	Meadowbank	7 yr (2010)	3.8	21	9, 10
Nunavut	Meliadine	10-15 yr (2017)	2.2	12	9, 10
Nunavut	Mary River[2]	21 yr (2017)	18	102	9, 8, 10, 6, 5
Nunavut	Kiggavik	25 yr (2020)	0.05	1	9
Nunavut	Izok Corridor	12 yr (2017)	2	11	6 (5, 8)
Nunavut	Hackett River	15 yr (2016)	3.6	20	6 (5, 8)
Nunavut	Back River	15 yr (2017)	1.8	10	6 (5, 8)
Nunavut	Roche Bay	15 yr (2017)	5-8	28–44	9 (5, 6, 8, 10)

[1] Foxtrot Project production start year estimated.

[2] Mary River Project announced a revised tonnage per year (3.5 Mt) in January 2013, but could return to the initial project of 18 Mt, and forecasted increase to 30 Mt per annum if economy is favourable.

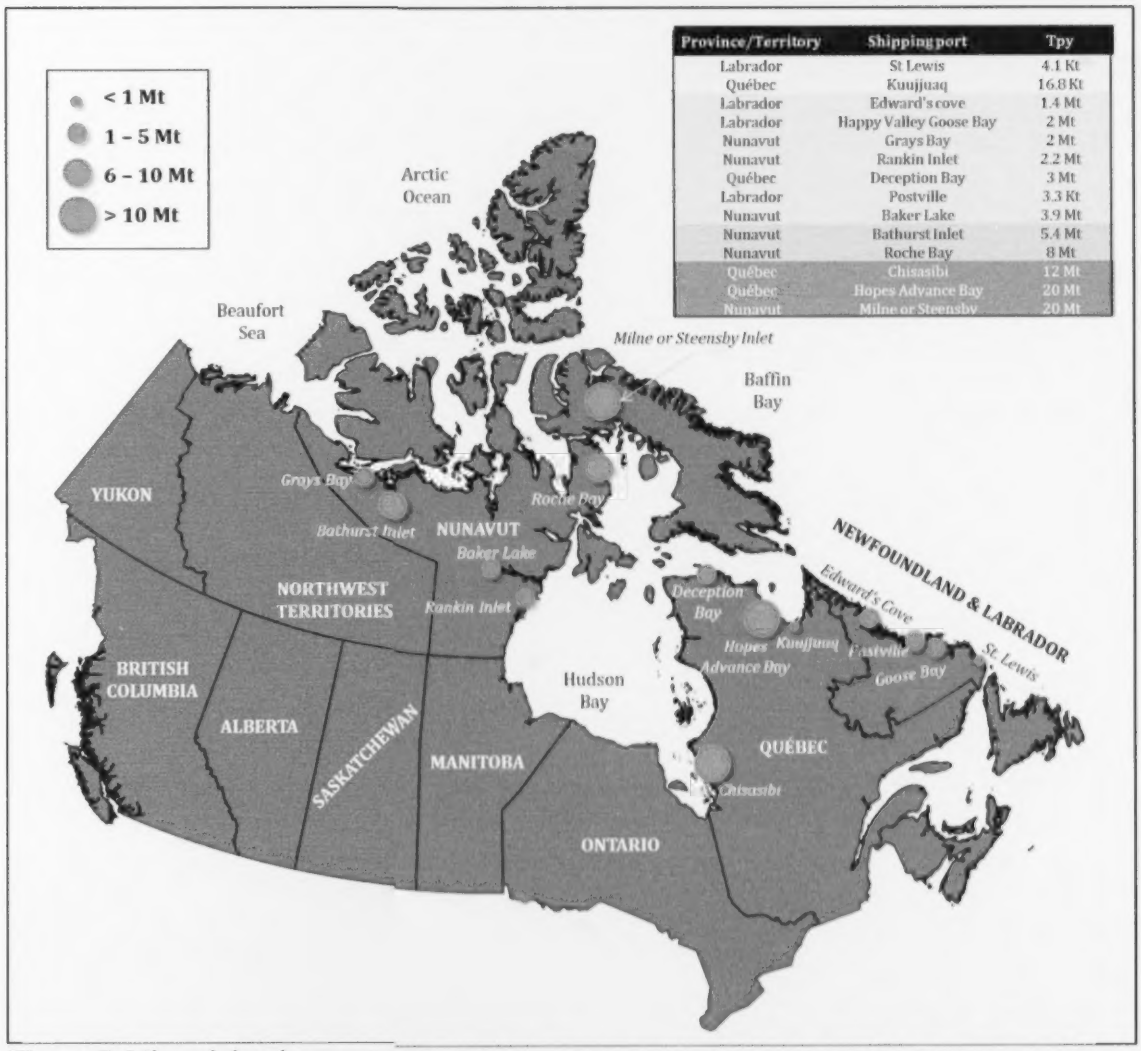


Figure 7. Mineral development projects in Canada's North shown as tonnage per year at most probable marine ports of export. Tonnage per year is based on peak production and is subject to change with fluctuations in the economy.

Oil and gas development

The management of oil and gas resources north of 60° latitude in the Northwest Territories, Nunavut, and offshore is under federal responsibility. The Northern Petroleum Resources Directorate of Aboriginal Affairs and Northern Development Canada (AANDC) works in partnership with Northern and Aboriginal governments and people to govern the allocation of Government (Crown) lands to the private sector for oil and gas exploration, to develop the regulatory environment, to set and collect royalties, and approve benefit plans before development takes place in a given area. The Energy Sector of NRCan oversees energy policy

for the Government of Canada. The National Energy Board (NEB) regulates oil and gas exploration and activities on frontier lands not otherwise regulated under joint federal/provincial accords, which include the Northwest Territories, Nunavut, Arctic offshore, Hudson Bay, West Coast offshore, Gulf of St. Lawrence, a portion of the Bay of Fundy, and onshore Sable Island. Prior to any work being initiated, authorization from the NEB is required. In offshore Newfoundland and Labrador, the oil and gas industry is regulated by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB). The Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) is responsible for the regulation of petroleum activities in the offshore Nova Scotia area. In 1972, the Government of Canada imposed a moratorium on offshore oil and gas activity in British Columbia due to concerns over the potential environmental impact, which has not been lifted since.

Oil and natural gas resource management in Canada occurs through several phases. Any company wishing to explore for oil and gas in the Canadian Arctic offshore must obtain an exploration licence through a bidding process for nominated land parcels of interest. Exploration licences are issued by the Minister of AANDC and granted for up to nine years and divided into two periods, with a drilling requirement in the first period of the term. An exploration licence is not required for surface exploration activity (seismic operations, geological surveying, and remote sensing). However, operations must receive approval from the appropriate regulatory agencies prior to any exploration. If oil and/or gas are discovered, a company can make a significant discovery declaration to the NEB and subsequently apply for a significant discovery licence to AANDC, which provides indefinite ownership to the discovery. Should the company plan to engage in oil and/or gas production on land held with a significant discovery licence, a production licence can be issued for discoveries deemed commercial for a period of 25 years and automatically renewed if still producing. Relevant permits and environmental assessments are also required before an oil or gas field begins production (Minerals and Petroleum Resources Directorate 2007).

Approximately 35% of Canada's remaining marketable resources of natural gas and 37% of remaining light crude oil is in northern Canada (NEB 2011a). These reserves are distributed in three major basins: the Central Mackenzie Valley, currently with 28 discoveries and one producing field (Norman Wells); the Arctic Islands, with 19 discoveries and one past-producing field (Bent Horn); and the Mackenzie Delta/Beaufort Sea, with 60 significant discoveries containing six trillion cubic feet of marketable gas (AANDC 2012a). In the Eastern Arctic (Baffin Bay, Hudson Bay [north of 60°N], and Foxe Basin), only one significant discovery has been made on the southeast Baffin shelf in the Davis Strait (Klose et al. 1982). This region has a mean, risked (potential), undiscovered oil and gas resource volume of 4.8 billion barrels oil, 33.7 trillion cubic feet gas and 0.7 billion barrels of natural gas liquids, approximately half that of Newfoundland and Labrador's offshore reserves (Schenk 2010, Arctic Subgroup of the Resource & Supply Task Group 2011).

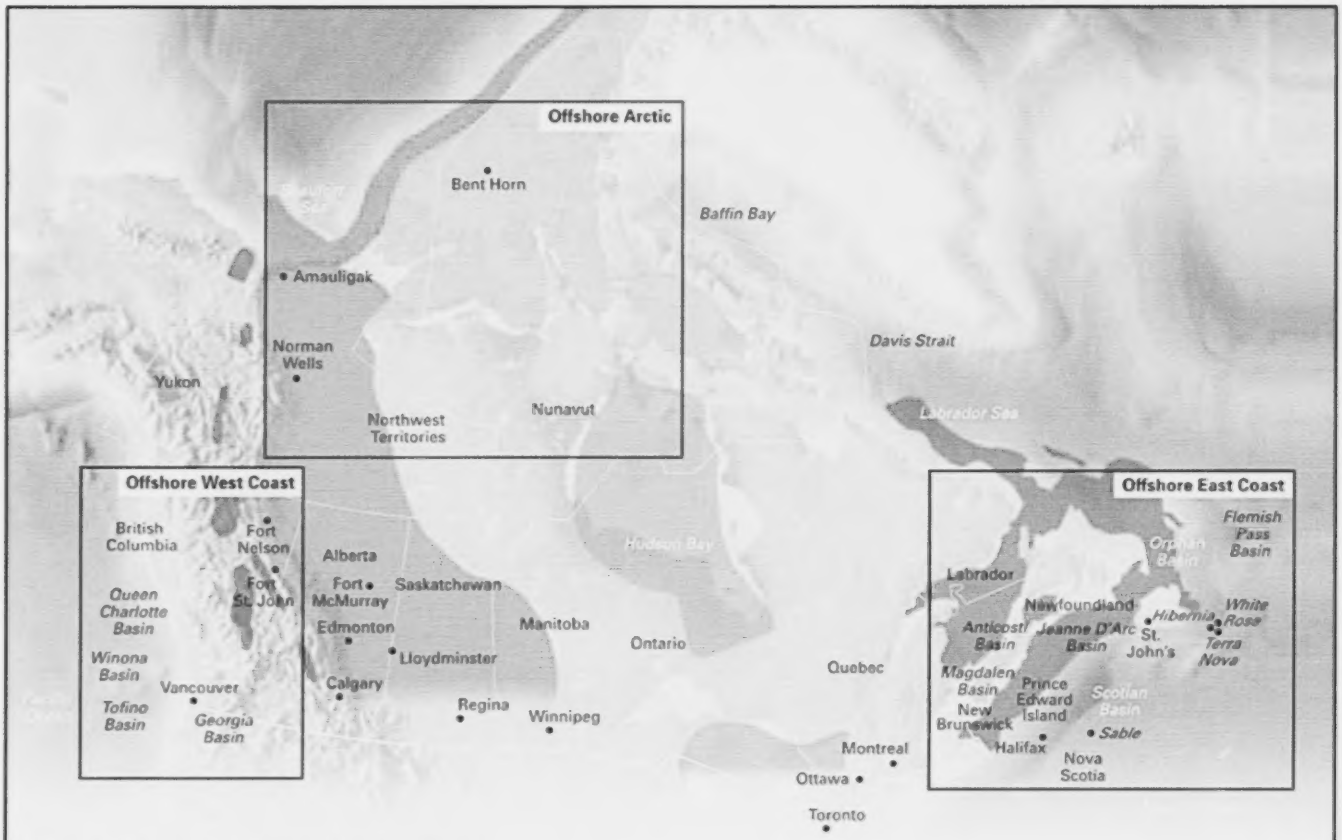
A complete list of all oil and gas rights granted in the Canadian Arctic (not including Labrador) which is updated annually is available via AANDC's Northern Petroleum Resources (Maps & Digital Files) web site (www.aadnc-aandc.gc.ca/eng/1100100036298/1100100036301; accessed 2 February 2013). Figure 8 illustrates Canada's seven major hydrocarbon regions.

As Canada's major onshore petroleum basins approach the end of production with declining supply, offshore reserves are expected to become a major source of crude oil and natural gas (Canadian Centre for Energy Information 2007). For this reason, the Government of Canada is encouraging reconnaissance research programs (Table 4) to better assess potential hydrocarbon reserves in all onshore and offshore basins and to maintain a high level of industry interest. For example, NRCan initiated a multi-year Geo-mapping for Energy and Minerals Program in 2008 to build a national geoscience database (Natural Resources Canada 2008). The goal was to guide the private sector for investment decisions and to better inform land-use decisions, such as the creation of parks and other protected areas. Similarly, AANDC have developed an online mapping program (Petroleum Environmental Management Tool (PEMT); www.aadnc-aandc.gc.ca/eng/1100100036632/1100100036636; accessed 2 February 2013) that includes generalized environmental and socio-economic information for selected Arctic regions to assist the environmental assessment required by a project and to inform land-use management decisions.

The main oil and gas activity in the Canadian Arctic over the next five years will likely be seismic surveying to evaluate potential hydrocarbon reserves. Two northern marine regions are expected to see increased activity in the near-term: the Labrador Sea and the Mackenzie Delta/Beaufort Sea region. Three multi-year seismic programs are currently underway or proposed for the Mackenzie Delta/Beaufort Sea, as well as one drilling program proposal and one producing gas field (Table 5). Given the number of exploration licences allocated in this region, several exploration programs will likely be proposed in upcoming years. Five multi-year seismic survey programs are active or proposed within the Labrador Sea (Table 4). Also, the National Energy Board is currently reviewing a five-year offshore marine seismic survey in Baffin Bay and Davis Strait scheduled to start once approval is obtained (Table 5).

Table 4. Summary of offshore oil and gas exploration research activities currently underway or proposed in the Canadian Arctic. Time frame refers to the open water season (See Appendix 4 for references).

Project name	Proponent	Location	Time frame	Description
Geo-mapping for Energy	Natural Resources Canada and partners	Baffin Bay, Hudson Bay, Foxe Basin, Mackenzie Delta, Sverdrup Basin, Yukon Basin	2008–2013	Airborne geophysical studies, seismic interpretation, studies of subsurface materials, petroleum systems analysis
Beaufort Sea Geoscience Research Program	Geological Survey of Canada and partners	Beaufort Sea	2013–2023	Seismic surveys, geologic sampling and oceanographic measurements; 2013 field activities (20d between Aug. and Oct.) would be part of a 10yr research program in the western Arctic; Research cruises are anticipated for 2016 and 2018



Canada's seven hydrocarbon regions

Region	*Percentage of Canada's estimated conventional hydrocarbon resources*
Western Canada Sedimentary Basin*	57%
Atlantic Margin	18%
Arctic Cratonic	10%
Arctic Margin	6%
Pacific Margin	4%
Intermontane	3%
Eastern Cratonic	2%

NOTE: These estimates were prepared by the Geological Survey of Canada to indicate the ultimate geological potential of sedimentary regions. They are useful to indicate the order of magnitude of various regions' resources, but are not the same as reserves that have been determined by actual drilling and can be produced economically. In some areas, such as the Western Canada Sedimentary Basin, a significant proportion of reserves have already been produced, but most of the resources remain in place. Also note that the estimates do not include the vast bitumen resources in the Alberta oilsands. Bitumen is a semisolid form of petroleum, dense and resistant to flow.

** Excluding oilsands bitumen*

Source: Geological Survey of Canada.

Figure 8. Canada's seven hydrocarbon regions and the percentage of conventional hydrocarbon reserves they are estimated to hold (reproduced with permission from Canadian Centre for Energy Information 2007).

Table 5. Summary of offshore oil and gas exploration and development operations currently underway or proposed in the Canadian Arctic. Time frame refers to the open water season (See Appendix 4 for references).

Project name	Proponent	Location	Time frame	Description
NorthEastern Canada 2D Seismic Survey	TGS, PGS, MKI[1]	Baffin Bay/ Davis Strait	2014[2]–2019	2D seismic reflection survey from end July to Nov; Air guns will be towed from the ship at depths of 6-10 m below the surface covering the area form offshore Lancaster Sound to the southern extremity of Baffin Island
Offshore Multi-Season Drilling Program on EL476 (Ajurak)	Imperial Oil Resources Ventures, ExxonMobil Canada	Beaufort Sea	Well to be drilled before July 2019	A typical well might be drilled over 3 or more summer drilling seasons (May to Nov.); Prospective drilling locations in water depths of 400–700 m; As early as ice conditions allow, the drilling rig and support vessels would be mobilized to the Beaufort Sea along with the necessary equipment, supplies, and fuel
Offshore Multi-Season Drilling Program on EL477 (Pokak)	Imperial Oil Resources Ventures, BP Exploration Operating Company	Beaufort Sea	Well to be drilled before Sept. 2020	A typical well could be drilled over 3 or more drilling seasons in water depths of 400–700 m; drilling rig and support vessels would be mobilized to well site, along with the necessary equipment, supplies, and fuel
Seismic survey program (EL484, EL485, EL488-EL493)	Franklin Petroleum	Beaufort Sea	2013–2020	3D seismic data over EL485 and 488-491 and possibly 2D seismic data in EL492 and 493 offshore Banks Island in 2013 and in subsequent years of lease
Gas production on PL06 (Ikhil gas field)	Inuvik Gas	Mackenzie Delta	2000–2025[3]	Gas is produced from 2 wells and delivered through a 50 km pipeline to Inuvik. South Parsons Lake (NWT) will likely replace Ikhil gas field

Table 5 cont'd. Summary of offshore oil and gas exploration and development operations currently underway or proposed in the Canadian Arctic. Time frame refers to the open water season (See Appendix 4 for references).

Project name	Proponent	Location	Time frame	Description
Labrador Shelf Seismic Project	Multi Klient Invest AS	Labrador Sea and Davis Strait	2011–2013	Seismic surveys
Labrador SPAN 2D Seismic, Gravity and Magnetic Survey	GX Technology Canada	Labrador Shelf and Slope	2013–2015	A regional Basin Span survey to examine very deep geological formations in the Labrador Shelf region (ca. 8,500 km of 2D seismic data each year)
Labrador Shelf Seismic Program on EL1109	Chevron Canada	Labrador Shelf	2010–2017	2D seismic surveys were planned for 2010 followed by 3D seismic and geohazard surveys from 2011 to 2017
Labrador Shelf Seismic Program on EL1106-1109	Husky Oil Operations	Labrador Shelf	2010–2017	2D and 3D seismic, geohazard surveys
Labrador Shelf Seismic Program on EL1107	Investcan Energy	Labrador Shelf	2010–2017	2D and 3D seismic surveys, well site and geohazard surveys, vertical seismic profiling

[1] TGS NOPEC Geophysical Company ASA (TGS), Petroleum Geo-Services (PGS) and Multi Klient Invest AS (MKI)
[2] Start date is pending approval from the National Energy Board
[3] Production licence is valid for 25 years and renewable if still under commercial production

Infrastructure

There are several infrastructure projects currently underway or planned in the Canadian Arctic that are not directly linked to mineral or oil and gas development (Table 6). Seven major projects are expected to become operational between 2013 and 2018.

Table 6. Summary of major infrastructure projects in Canada's North planned from 2013 until 2018. Project start dates are time frames are subject to change.

Project name	Proponent	Location	Time frame	Description
Arctic/Offshore Patrol Ship Project	Gov. of Canada	Canadian Arctic	2018–2023 (to complete construction of all ships)	Construction and operation of 6–8 Arctic Offshore Patrol Ships (Polar Class 5)
Naval Facility	Gov. of Canada	Nanisivik, Nunavut	2017 (operational)	Staging area for naval and other government vessels
Canadian Forces Arctic Training Centre	Gov. of Canada	Resolute Bay, Nunavut	2013 (operational)	Multi-purpose facility to provide specialized training for cold weather survival, military operations, etc.
High Arctic Research Station	Gov. of Canada	Cambridge Bay, Nunavut	2018 (operational)	Multi-disciplinary facility for Arctic science and technology
Small vessel harbour	Gov. of Canada	Pangnirtung, Nunavut	2013 (operational)	Provide expanded harbour infrastructure to accommodate commercial fisheries, annual sealift, etc.
Lower Churchill Hydroelectric Project	Nalcor Energy	Newfoundland–Labrador	2017 (operational)	Project includes a 35 km subsea cable crossing the Strait of Belle Isle from Forteau Point, Labrador, to Shoal Cove, Newfoundland
Fibre optic telecommunication system	Arctic Fibre	Canadian Arctic	2014 (if approved)	Construction of a 15,600 km subsea fibre optic cable between Japan and England via the Bering Strait, Beaufort Sea, and Canadian Arctic

LABRADOR

Mineral resource development

Newfoundland and Labrador's economy is diverse, natural-resource-based, and export-oriented. It is also located in a strategic location with proximity to Atlantic shipping lanes (USA, Europe, and Asia). The Mines and Energy Branch within the Natural Resources Department of the Government of Newfoundland and Labrador is responsible for the supervision, control, and direction of all matters concerning exploration and development of mineral and energy resources as well as related industry developments in the province. Any party seeking to explore or exploit mineral reserves on Labrador Inuit Lands must apply to both the Nunatsiavut Government and the Province of Newfoundland and Labrador. The minerals sector of Newfoundland and Labrador is preparing for major expansion, particularly in Labrador, with a number of advanced projects, rejuvenation of existing mines, and recent discoveries. The Department of Natural Resources foresees $10–15 billion of investment in mine development over the next decade based on approved industry planning, feasibility studies, and preliminary economic assessments of prospective deposits (Department of Natural Resources of Newfoundland and Labrador 2012).

In 2008, the Nunatsiavut Government imposed a moratorium on the working, production, mining, and development of uranium on Labrador Inuit lands. The moratorium was required to review exploration and development procedures. Companies with uranium-holding properties consequently put their prospecting on hold during this period, focusing efforts on other assets. In 2011, this three-year moratorium was lifted, which will incent companies to push their uranium projects forward, provided there is a demand.

Currently, Labrador has four producing mines: Voisey's Bay nickel mine, James iron mine, The Iron Ore Company of Canada iron mine, Wabush mines, and one mine under construction (DSO iron mine), which lies on the Labrador–Québec border. Of these mines, only Voisey's Bay mine ships ore off the Labrador coast destined to a processing facility in Placentia Bay, Newfoundland (Table 7). The other mines transport ore south via road or rail to the port of Sept-Îles. Voisey's Bay mine ships approximately 1.4 Mt of concentrate annually, with up to nine shipments from the end of January to early April and from the end of May to early December (Voisey's Bay Mine Marine Traffic Schedule: www.vbnc.com/MarineTrafficSchedule.asp).

Labrador has several mining projects in exploration stage, seven of which are in proximity to the Labrador coast (Table 7). These include the Henley Harbour project, the Red Wine Complex, Pope's Hill project, Red Wine project, C-Zone Corridor, Two-Time projects (part of the Central Mineral Belt Division property), and Seal Lake (Table 7, Fig. 9). There is no guarantee that these projects will ship ore to the Labrador coast since other infrastructure options (the Trans-Labrador Highway, ports on the north shore of the Gulf of St. Lawrence, and Labrador Railway) may prove to be more economically viable. Projects in development phase (i.e., that have prepared a preliminary economic assessment, feasibility study, or environmental impact assessment) include the Foxtrot project, which sits within the Port Hope Simpson Rare

Earth Element District, the Michelin project, and the Churchill River project. The Strange Lake project, which lies on the Québec–Labrador border, is undergoing feasibility studies, and there are plans to construct mine infrastructure in Québec and a 165 km road to port facilities on the Labrador coast.

Between 2013 and 2018, three major mineral projects in Labrador are expected to enter production. Shipping ports will be Edward's Cove, Happy Valley-Goose Bay, and most likely the port of St. Lewis on the southeast tip of Labrador.

Table 7. Mine projects in Labrador under exploration, development, or production that have, or will potentially have a marine transportation component. LOM: life of mine; TPY: tonnage per year; REE: rare earth elements; HV-GB: Happy Valley-Goose Bay; PFA: Preliminary Feasibility Study; PEA: Preliminary Economic Assessment; MR-TR: Mineral Resource Technical Report.

Project name (mineral)	Company/Proponent	Mine location	Stage	LOM (start yr)	TPY (Mt)	Shipping destination
Voisey's Bay Mine (Ni, Cu, Co)	Vale Newfoundland and Labrador	35 km S of Nain	Production	30 yr (2005)	1.4	Processing plant in Placentia Bay, NL
Churchill River Project (Fe)	Grand River Ironsands	HV-GB	Development; PEA 2013	25 yr (2015)	2	USA and Europe
Foxtrot Project (REE)	Search Minerals	8 km NW of St. Lewis	Development; PEA 2012	10 yr	0.001	Market
Michelin Project (U)	Paladin Energy	40 km S of Postville	Development; PEA 2009	18 yr (2018)	0.003	Trucked to HV-GB, then trucked to Montreal, then by train or ship to refinery
Strange Lake B-Zone (REE)	Quest Rare Minerals + Search Minerals	220 km NE of Schefferville	Development; PFS 2013	30 yr (2016/17)	0.02	
C-Zone Corridor (U, V)	Crosshair Energy	95 km SW of Postville	Exploration; MR-TR 2011			
Two-Time Zone (U)	Crosshair Energy	85 km SW of Postville	Exploration; MR-TR2009			
Seal Lake (Cu, Ag)	Playfair Mining	140 km NW of HV-GB	Exploration; MR-TR 2010			
Henley Harbour (REE)	Search Minerals	Henley Harbour	Early exploration			
Red Wine Complex (REE)	Search Minerals + Great Western Minerals Group	100 km NE of Churchill Falls	Early exploration			
Pope's Hill (REE)	Silver Spruce Resources	100 km W from HV-GB	Early exploration			
Red Wine Project (REE)	Canada Rare Earth + Playfair Mining	100 km NE of Churchill Falls	Early exploration			

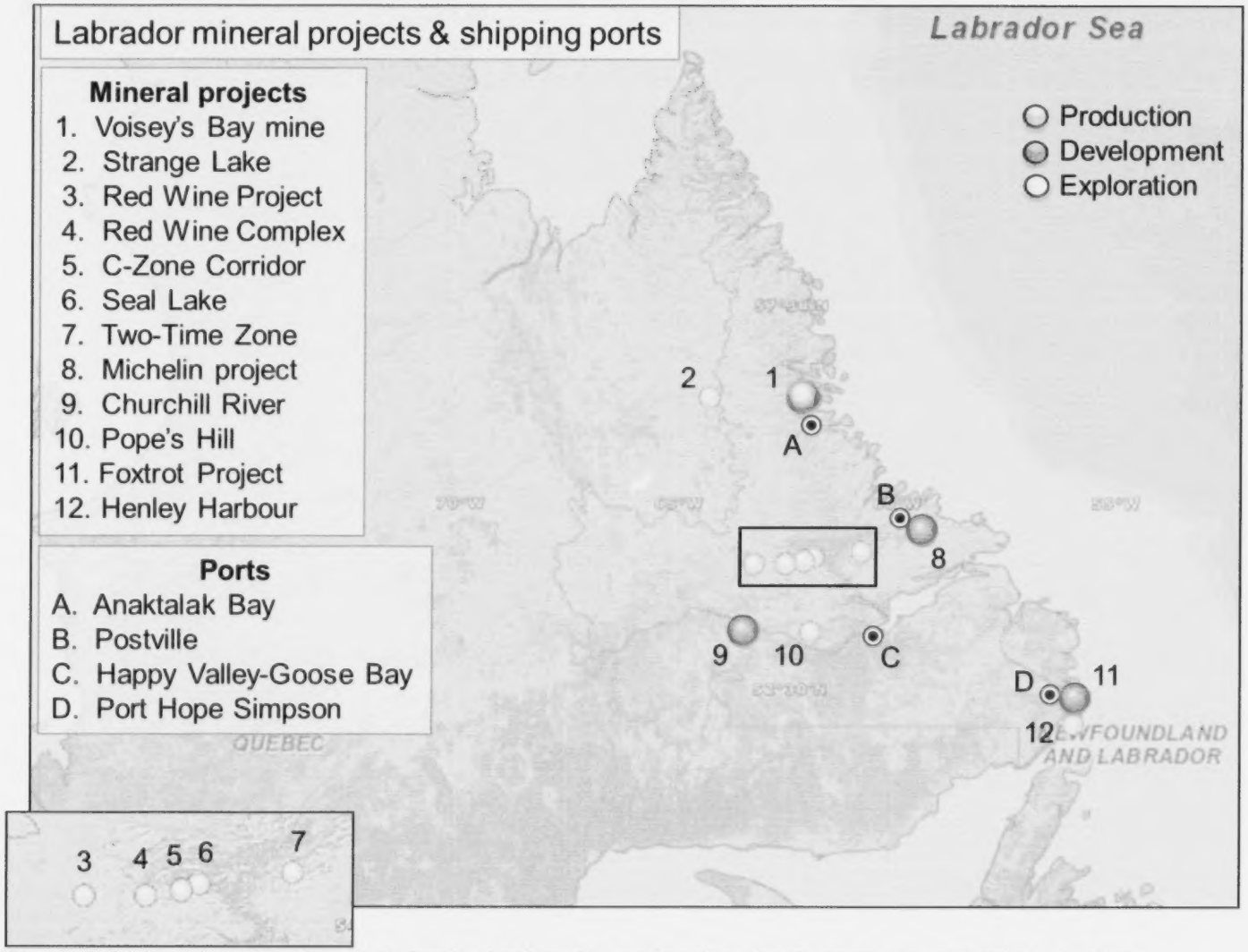


Figure 9. Major mineral projects in Labrador (undergoing exploration, development, or production) that have or will likely have a marine transportation component. Refer to Table 7 for project descriptions.

Oil and gas development: offshore Labrador

In early 2013, following seismic and satellite exploration off the coast of Labrador, Nalcor Energy (www.nalcorenergy.com) announced the discovery of three new basins with reasonably high probabilities of bearing hydrocarbons. In addition, a fourth previously discovered basin was found to be much larger than originally thought. The next step is to provide oil and gas companies with this data and proceed with a bidding process on prospective land parcels. There were five significant discovery licences issued on 15 January 2013 in offshore Labrador (Snorri J-90, Hopedale E-33, North Bjarni F-06, Bjarni H-81, Gudrid H-55; Fig. 10). There are currently four multi-year seismic programs active in offshore Labrador and one program under review by the C-NLOPB (Table 8).

Table 8. Multi-year seismic programs active and proposed for offshore Labrador 2010–2017. EL: Exploration licence. Additional information can be found on the C-NLOPB web site under Environment (Project-Based Environmental Assessments; www.cnlopb.nl.ca/env_project.shtml).

Project name	Company	Location	Time frame
Offshore Labrador Shelf 2D Seismic Survey Project	Multi Klient Invest AS	Labrador Sea and Davis Strait	July–Nov, 2011–2013
Chevron Canada Resources Offshore Labrador Seismic Program	Chevron Canada Ltd	Northeast of Makkovik, Labrador Shelf (EL1109)	July–Nov 2010–2017
Husky Energy Labrador Shelf Seismic Program	Husky Oil Operations Ltd	Labrador Shelf (EL1106)	July–Nov 2010–2017
Investcan Energy Corporation Labrador Shelf Seismic Program	Investcan Energy Corp.	Labrador Shelf (EL1107)	June–Nov 2010–2017
GXT 2013-2015 LabradorSPAN 2D Seismic, Gravity and Magnetic Survey*	GX Technology Canada Ltd	Labrador shelf and slope, between 61° and 50.5° N	June–Nov 2013–2015

* under review as of 30 March 2013 by the C-NLOPB.

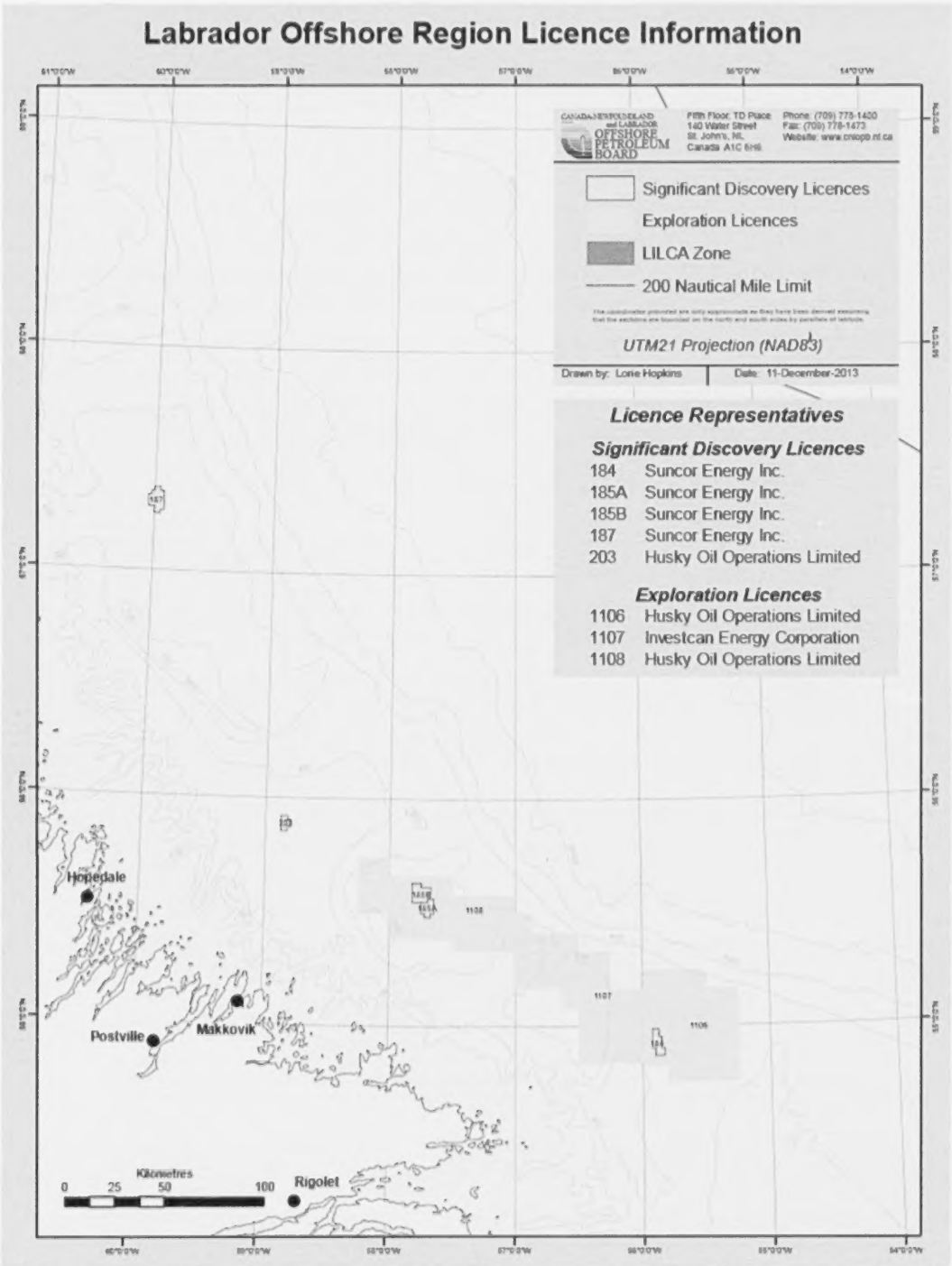


Figure 10. Significant discovery licences (pink) and exploration licence areas (green) in the Labrador offshore region. Companies holding licences are indicated on the right (reproduced with permission from C-NLOPB 2013).

QUÉBEC

Mineral resource development

In June 2009, the Minister for Natural Resources and Wildlife launched *Québec's Mineral Strategy* in order to prepare the future of Québec's mineral sector (Government of Québec 2009). Mines are a major economical asset for Québec and the *Mineral Strategy* aims to promote exploration and development of new mining projects, and to encourage mine expansion in northern Québec. The Government of Québec intends to accelerate development in this region by improving accessibility and advancing our understanding of mineral potential. Québec is strategically located near heavily populated areas and major industries, and benefits from access to Europe and Asia via its deep-water ports. The Ministre des Ressources Naturelles et de la Faune of the Government of Québec is responsible for mining extraction activities (permits, titles, mining rights, etc.) in Québec. The Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs is responsible for activities related to the environment and environmental impacts. Prospectors wishing to explore or exploit lands within The James Bay and Northern Quebec Agreement (territorial regions of James Bay and Nunavik) are also subject to mining policies imposed by this group.

In May of 2011, the Québec Government announced their 25-year Plan Nord, one of the largest economic, social, and environmental projects Québec has ever proposed. This program has undergone minor revision with the change of government in September 2012 although the objectives remain largely intact. One of the initiatives of the Plan Nord is to develop an integrated transportation network to improve accessibility to major territories in Québec (Ministère des Ressources Naturelles et de la Faune 2011). The government will prioritize transportation infrastructure schemes that provide access to the regions with the greatest economic potential. For instance, Québec intends to strategically position itself to take advantage of the Northwest Passage, a maritime route that will significantly reduce shipping time between Asia and Europe. To do so, the government intends to conduct feasibility studies for a road or rail link from Kuujjuaq southward (rail to Schefferville and/or road to central Québec), as well as profitability studies for a deep-water port in Whapmagoostui-Kuujjuarapik with a land link to Radisson (Government of Québec 2011). The Makivik Corporation and the Kativik Regional Government want to see the construction of deep-sea port in Kuujjuaq, Ungava Bay, by 2035. Feasibility studies are underway (Kativik Regional Government and Makivik Corporation. 2010). If these projects prove feasible, this will open up new corridors within Québec and allow industry to gain access to strategically placed ports. A new mining tax might be imposed by the provincial government which could influence some mining developments; however, this is difficult to predict (Government of Québec 2013).

As of October 2012, Québec had 24 operating mines (Ministère des Ressources Naturelles et de la Faune 2012a), only one of which ships ore using a marine route in northern Québec (Raglan mine). The other 23 mines ship ore via road or rail routes to southern refineries or ports and then to appropriate markets. There are 40 major mining projects in exploration or development phase in Québec (Ministère des Ressources Naturelles et de la Faune 2012b), five of which plan to export ore via northern deep-water ports (Table 9). By 2014, 2.9 Mt will

possibly be shipped annually out of the Deception Bay port in northern Québec. New deep-water port facilities at Pointe Breakwater on the western coast of Ungava Bay will potentially be built to service the 10–20 Mt per year Hopes Advance Bay mine (Golder Associés Ltée 2012). Another 16,850 t per year is planned to be shipped out of Kuujjuaq from the Eldor project. Finally, the Duncan Lake project foresees export of 12 Mt annually from a port to be built in Chisasibi on the eastern shore of James Bay (Table 9). This would increase the shipping tonnage through Hudson Strait to 24.9 Mt annually starting in 2017; this would be the equivalent of 138 shipping transits with an 180,000 DWT vessel.

Furthermore, there are at least 39 exploration projects spread over northern and western Nunavik as well as the James Bay region and in proximity to the shoreline (Table 9). Although the outcome of these exploration properties remains unknown and depends largely on economic factors, they are included to better reflect the general regions in Québec which will likely experience strong mineral development in the future (Fig. 11).

Table 9. Mine projects in northern Québec under exploration, development, or production that have, or will potentially have a marine transportation component. LOM: life of mine; TPY: tonnage per year; Mt: million tonnes; REE: rare earth elements; PGE: platinum-group elements; PEA: Preliminary Economic Assessment; PFS: Preliminary Feasibility Study; PEP-TR: Proposed Exploration Program-Technical Report; MR-TR: Mineral Resource-Technical Report; TBD: to be determined.

Project name (mineral)	Company/Proponent	Mine location	Stage	LOM (start yr)	TPY (Mt)	Shipping destination
Raglan mine (Ni)	Xstrata Nickel	100 km S of Deception Bay	Production	25 yr (1997)	1.3	Quebec City
Nunavik Nickel (Ni, Cu, Pd, Pt)	Canadian Royalties	30 km S of Raglan mine	Construction	13 yr (2013)	1.6	Finland
Eldor Project (REE)	Commerce Resources	130 km S of Kuujjuaq	Development; PEA 2012	25 yr (2016)	0.02	Hydrometallury plant (TBD) and then to markets (likely China)
Hopes Advance Bay (Fe, Ti, V)	Oceanic Iron Ore	Near Aupaluk, Ungava Bay	Development; PFS 2012	30+ yr (2017)	10-30	Steel mills in Europe and Asia
Duncan Lake Project (Fe)	Century Iron Mines + WISCO	50 km S of Radisson	Development; PEA 2013	20 yr (2017)	12	Europe (30% of pellets) and China (70% of pellets)
Strange Lake B-Zone (REE)	Quest Rare Minerals + Search Minerals	220 km NE of Schefferville	Development; PFS 2013	30 yr (2016/17)	0.015	Market (TBD)
Hawk Ridge (Cu, Ni, Pt, Pd, Au)	Nickel North[1]	135 km NW of Kuujjuaq	Exploration; PEP-TR 2012			
Great Whale Iron (Fe)	Niocan	65 km SE of Kuujjuarapik	Exploration; MR-TR 2006			
Opinaca A + B (Au)	Everton Resources + Aurizon Mines + Azimut[2]	350 km N of Matagami	Exploration; Drilling in 2013			
Dieter Lake (U)	Fission Energy	150 km N of Hydro Quebec Reservoir LG-4	Exploration; MR-TR 2011			
Raglan property (Cu, Ni, PGE)	Jien Nunavik Mining[3] + Goldbrook Ventures	95 km S of Salluit	Exploration; MR-TR 2010			
West Raglan (Ni)	True North Nickel	80 km S of Salluit	Exploration; Drilling in 2013			

Table 9 cont'd. Mine projects in northern Québec under exploration, development, or production that have, or will potentially have a marine transportation component. LOM: life of mine; TPY: tonnage per year; Mt: million tonnes; REE: rare earth elements; PGE: platinum-group elements; PEA: Preliminary Economic Assessment; PFS: Preliminary Feasibility Study; PEP-TR: Proposed Exploration Program-Technical Report; MR-TR: Mineral Resource-Technical Report; TBD: to be determined.

Project name (mineral)	Company/Proponent	Mine location	Stage	LOM (start yr)	TPY (Mt)	Shipping destination
Misery Lake Project (REE)	Quest Rare Minerals	120 km S of Strange Lake Project	Early exploration			
Nantais (Au)	Azimut	80 km S of Raglan nickel mine	Early exploration			
Agvakvik (Cu)	Azimut	N of Kangirsuq	Early exploration			
Rex (Cu, Au, Ag, REE)	Azimut	130 km E of Puvirnituq	Early exploration			
Rex South (Cu, Au, Ag, W)	Azimut + Aurizon Mines	145 km E of Puvirnituq	Early exploration			
Pelican (Cu)	Azimut	E of Rex South property	Early exploration			
Arnaud (Cu)	Azimut	SE of Pelican property	Early exploration			
NCG (Cu, Au, REE)	Azimut	140 km E of Puvirnituq	Early exploration			
Diana (Cu, Co, REE)	Azimut + Valencia Ventures	40 km NW of Kuujjuaq	Early exploration			
North Rae (U)	Azimut	20 km E of Ungava Bay	Early exploration			
South Rae (U)	Azimut + Majescor Resources	60 km E of Ungava Bay	Early exploration			
Daniel Lake (U)	Azimut	20 km E of Ungava Bay	Early exploration			
Kangiq (U)	Azimut + Central Uranium	40 km E of Ungava Bay	Early exploration			
Kativik (U)	Azimut + Nemaska[4]	West and central Nunavik	Early exploration			

Table 9 cont'd. Mine projects in northern Québec under exploration, development, or production that have, or will potentially have a marine transportation component. LOM: life of mine; TPY: tonnage per year; Mt: million tonnes; REE: rare earth elements; PGE: platinum-group elements; PEA: Preliminary Economic Assessment; PFS: Preliminary Feasibility Study; PEP-TR: Proposed Exploration Program-Technical Report; MR-TR: Mineral Resource-Technical Report; TBD: to be determined.

Project name (mineral)	Company/Proponent	Mine location	Stage	LOM (start yr)	TPY (Mt)	Shipping destination
West Minto (U)	Azimut + Majescor Resources	150 km ESE of Inukjuak	Early exploration			
North and South Minto (U)	Azimut + Rukwa Uranium	Central QC, mid-way between Hudson Bay and Ungava Bay	Early exploration			
Central Minto (U)	Azimut + Central Uranium	Central Nunavik	Early exploration			
Hudson Bay (U)	Azimut + Silver Spruce Resources	15 km from Umiujaq	Early exploration			
South Bienville (U)	Azimut + Central Uranium	200-300 km E of Hudson Bay coast	Early exploration			
West Bienville (U)	Azimut + Channel Resources	160 km N of the La Grande-4 airport	Early exploration			
Qassituq (Cu, Au)	Azimut	Raglan region	Early exploration			
Kovik (Cu, Au)	Azimut	Raglan region	Early exploration			
Tasinga (Cu, Au)	Azimut	Raglan region	Early exploration			
Opinaca D (Au)	Azimut + Dynasty Gold	14 km NNW of Eleonore mine	Early exploration			
Eleonore South (Au)	Azimut + Les Mines Opinaca + Eastmain[5]	W of Opinaca B	Early exploration			

Table 9 cont'd. Mine projects in northern Québec under exploration, development, or production that have, or will potentially have a marine transportation component. LOM: life of mine; TPY: tonnage per year; Mt: million tonnes; REE: rare earth elements; PGE: platinum-group elements; PEA: Preliminary Economic Assessment; PFS: Preliminary Feasibility Study; PEP-TR: Proposed Exploration Program-Technical Report; MR-TR: Mineral Resource-Technical Report; TBD: to be determined.

Project name (mineral)	Company/Proponent	Mine location	Stage	LOM (start yr)	TPY (Mt)	Shipping destination
Wabamisk (Au)	Azimut Exploration + Goldcorp	80 km S of Eleonore mine	Early exploration			
Eastmain West (Cr, PGE)	Azimut Exploration	290 km N of Chibougamau	Early exploration			
Gerido (Cu, Ni)	Jien Nunavik Mining + Canadian Royalties	SW of Kuujjuaq	Early exploration			
Baie Payne (Ni)	Virginia + Anglo American	Kangirsuk	Early exploration			
Lac Fagnant (Au)	Virginia	150 km NNE of Radisson	Early exploration			
Duquet (Au, Ag, Co, Zn, Cu)	Virginia + SOQUEM + Miramar Mining	100 km E of Puvirnituq	Early exploration			
Ménarik (Ni)	Pro-Or + Everett Resources	45 km SE of Radisson	Early exploration			
Ytterby (REE)	Midland Exploration + Japan Oil, Gas and Metals National Corporation	200 km NE of Schefferville	Early exploration			

[1] Nickel North Exploration; [2] Azimut Exploration; [3] Jien Nunavik Mining Exploration; [4] Nemaska Exploration; [5] Eastmain Resources

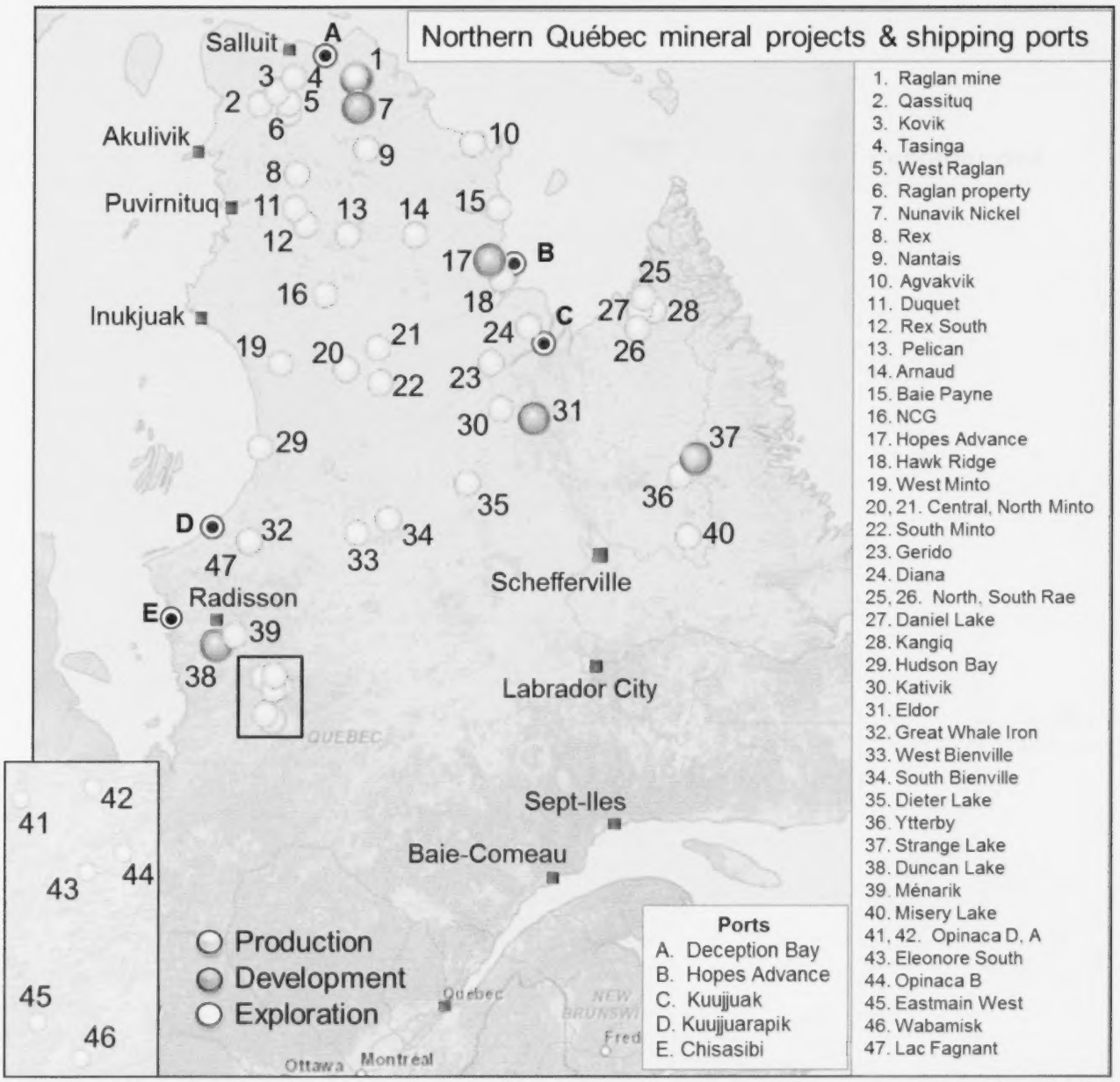


Figure 11. Major mineral projects in northern Québec under exploration, development, or production that have or will potentially have a marine transportation component. Deep-sea ports in northern regions currently in use or proposed to be constructed are indicated as letters.

NUNAVUT

Mineral resource development

Nunavut is recognized as one of the most attractive territories in Canada for resource investment and development in Canada. The Government of Canada introduced *Canada's Northern Strategy* in 2007 to exercise Arctic sovereignty, protect environmental heritage, promote social and economic development, and regulate the devolution of Northern governance (devolution is the transfer of provincial-level responsibilities from the federal government to the territories [www.northernstrategy.gc.ca]). The Government of Canada ("the Crown") administers mineral rights for 98% of Nunavut. AANDC governs the location of Crown land mineral claims and subsequent leases through the Northwest Territories and Nunavut Mining Regulations. The Inuit hold mineral rights on the remaining 2% of Nunavut territory (Inuit Owned Lands). Surface title to Inuit Owned Land is held by one of the three Regional Inuit Associations while subsurface title to Inuit Owned Land is administered by Nunavut Tunngavik Incorporated (NTI). The Nunavut Planning Commission (NPC) is responsible for the development, implementation, and monitoring of land use plans that regulate resource use and development in the Nunavut Settlement Area. The Nunavut Impact Review Board (NIRB) assesses the potential biophysical and socio-economic impacts of proposed development projects in the Nunavut Settlement Area prior to required project approvals.

Currently, Nunavut has only one producing mine, the Meadowbank gold mine, located north of Baker Lake in the Kivalliq Region, which exports approximately 3.8 Mt annually. The NPC expects over 10 major mineral projects to enter production between 2013 and 2020 (NPC 2011). Among these are the Meliadine mine (2.2 Mt/yr), Mary River mine (initially an 18–30 Mt/yr project, but reduced to 3.5 Mt in early 2013 due to a weakened economy), Kiggavik mine (52 Kt/yr), Izok Corridor mine (2 Mt/yr), Hackett River mine (3.6 Mt/yr), Back River mine (1.8 Mt/yr), and Roche Bay mine (5–8 Mt/yr; Table 10, Fig. 12, 13, 14). Meadowbank and Meliadine will use the same transport system (via air) to export ore to southern markets and will use marine shipping for fuel, cargo, and other material from Montreal/Québec to Baker Lake via Hudson Strait and from Churchill to Baker Lake via barge through Hudson Bay. Mary River's iron mine will potentially utilize two ports on Baffin Island over the course of its mine life, with the ore destined primarily to European steel mills. The port in Steensby Inlet (northern Foxe Basin) is planned to accommodate cape-sized vessels, specially designed to transport ore year-round. The construction phase should take four years (Baffinland Iron Mines Corporation 2012). Kiggavik plans on shipping uranium ore to southern Canada by air or by barge during the open-water season. The primary marine transport routes being considered for Kiggavik are through Hudson Strait and Hudson Bay to Churchill (or Chesterfield Inlet) via ocean-going vessels and from Churchill (or Chesterfield Inlet) to Baker Lake via barge. The Izok Corridor project transport route is likely a 350 km road connecting the mine to a new port at Grays Bay on the Coronation Gulf with the capacity to ship 650,000 tonnes per year (Minerals and Metals Group 2012). Shipping would occur through the Northwest Passage to smelters in Europe and Asia for further processing. The Hackett and Back River projects are planning on utilizing new port facilities in Bathurst Inlet (Bathurst Port and Road Project) to export ore via the Northwest Passage to

Europe and Asia, depending on where the market are. Roche Bay mine will ship ore from Roche Bay Harbour south through Foxe Basin and likely east through the Northwest Passage to China. Port facilities are being planned to service the Roche Bay iron ore mining project on the east coast of Melville Peninsula in Nunavut. The project plans to enter construction phase in 2013 and to ship ore by 2017 (Advanced Explorations Inc. 2012, 2013). Lupin gold mine, Ulu gold mine, and Jericho diamond mine, all within the Kitikmeot Region of Nunavut, have export planned via a terrestrial route to Yellowknife, NWT. However, given their proximity to Bathurst Inlet and its proposed port infrastructure, these mines would have the option to divert shipments to this northern port.

Another ca. 24 projects are in advanced exploration stage (Table 10, Fig. 12, 13, 14; i.e., have completed N3-101 Technical Reports on Mineral Reserves), some of which are dependent on new port facilities for their operations to progress to the production stage. In particular, the Haig Inlet iron project plans to barge iron ore off the Belcher Islands for further processing at a year-round port on the Québec coastline in Hudson Bay, to then be shipped to market (Canadian Orebodies Inc. 2012). The Seal Zinc and Storm Copper projects would require the construction of a port at Aston Bay (northwest Somerset Island) to service shipments likely to China. A major coal project on Ellesmere Island completed a shipping study in 2012, concluding that the optimal route to export coal from Eureka to Nova Scotia would be through Norwegian Bay to Jones Sound and then south through Baffin Bay and the Labrador Sea. There have also been plans to build a deep-water port in Iqaluit, Nunavut's capital. With the growth of Iqaluit and the evolution of Arctic transportation, improved marine facilities will be required for more efficient import and export as well as for tourism, recreation amenities, and safety. The city of Iqaluit has studied the feasibility of a new deep-sea port facility and a small craft port at the end of the West 40 causeway and Inuit Head (Aarluk Consulting Inc. et al. 2005, NEAS Group 2012). This port could service mineral development projects in the area (e.g., Chidliak and Qilaq diamond mines) and act as a main gateway to the Northwest Passage from the east. Also, development of a deep-water port facility in Rankin Inlet has been identified as a key priority for existing and future mining activities and economic development in the areas around the community (Canadian Northern Economic Development Agency 2012).

There are an additional ca. 25 projects in Nunavut undergoing early stage exploration and prospecting, and it is difficult to predict whether these projects will become economically viable (Table 10). However, illustrating the location of these exploration sites provides an idea of which areas in Nunavut might see mine development in the future (Fig. 12, 13, 14; see also a map of Mineral Exploration Projects in the Northwest Territories and Nunavut created by the NWT & Nunavut Chamber of Mines, 2012: www.miningnorth.com/wp-content/uploads/2012/05/NWT-NU_2011_Exploration_Map_B_W_11x17.pdf; Accessed 25 January 2013).

Table 10. Mine projects in Nunavut under exploration, development or production, that have or will potentially have a marine transportation component. LOM: life of mine; TPY: tonnage per year; Mt: million tonnes; REE: rare earth elements; PEA: Preliminary Economic Assessment; P/DFS: Preliminary/Definitive Feasibility Study; DEIS: Draft Environmental Impact Statement; MR-TR: Mineral Resource-Technical Report; CRS: Conceptual Resource Study; DMND: diamonds; TBD: to be determined.

Project name (mineral)	Company/Proponent	Mine location	Stage	LOM (start yr)	TPY (Mt)	Shipping destination
Meadowbank (Au)	Agnico-Eagle	70 km N of Baker Lake	Production	7 yr (2010)	3.8	Southern markets
Meliadine (Au)	Agnico-Eagle	25 km NW of Rankin Inlet	Development; FS 2014	10-15 yr (2017)	2.2	Southern markets
Mary River (Fe)	Baffinland	160 km S of Pond Inlet	Construction 2013	21 yr (2017)	18-30	Europe and Asia
Kiggavik (U)	AREVA[1] + JCU[2] + DAEWOO	80 km W of Baker Lake	Development; DEIS 2012	17 yr (2020)	0.05	Southern markets
Izok Corridor (Zn, Cu)	Minerals and Metals Group	Kitikmeot region, near Kugluktuk	Development; initiated DFS in 2012	12 yr (2017)	2	Europe and Asia
Hackett River (Zn, Cu, Pb, Ag, Au)	Xstrata Zinc	75 km SW of Bathurst Inlet	Development; started PFS 2012	15 yr (2016)	3.7	Market (TBD)
Back River (Au)	Sabina Gold & Silver	50 km SE of Hackett River Project	Development; PEA 2012	15 yr (2017)	1.8	Market (TBD)
Roche Bay (Fe)	Advanced Exporation + Roche Bay PLC	Roche Bay	Development; FS 2012	15 yr (2017)	5-8	Market (TBD)
Three Bluffs Gold (Au)	North Country Gold	180 km NE of the Meadowbank mine	Exploration; MR-TR 2012; planning PEA 2013			
Hope Bay (Au)	TMAC Resources	110 km SW of Bathurst Inlet	Exploration; PFS planned for 2013			
Angilak (U)	Kivalliq Energy	225 km S of Baker Lake	Exploration; MR-TR 2013; planning PFS 2014			
Ellesmere Island Coal (coal)	Canada Coal	Fosheim Peninsula and Strathcona Fiord	Exploration; MR-TR 2012			

Table 10 cont'd. Mine projects in Nunavut under exploration, development or production, that have or will potentially have a marine transportation component. LOM: life of mine; TPY: tonnage per year; Mt: million tonnes; REE: rare earth elements; PEA: Preliminary Economic Assessment; P/D FS: Preliminary/Definitive Feasibility Study; DEIS: Draft Environmental Impact Statement; MR-TR: Mineral Resource-Technical Report; CRS: Conceptual Resource Study; DMND: diamonds; TBD: to be determined.

Project name (mineral)	Company/Proponent	Mine location	Stage	LOM (start yr)	TPY (Mt)	Shipping destination
Haig Inlet Iron (Fe)	Canadian Orebodies	Belcher Islands	Exploration; MR-TR 2012			
Tuktu Iron (Fe)	Advanced Exploration	60 km N of Roche Bay	Exploration; MR-TR 2012			
Fraser Bay (Fe)	Westville Metals + Roche Bay PLC	180 km E of Kugaaruk	Exploration; MR-TR 2011			
Qilalugaq (DMND)	Stornoway Diamonds	1 km N of Repulse Bay	Exploration; MR-TR 2012			
Chidliak (DMND)	Peregrine Diamonds + De Beers	120 km NE of Iqaluit	Exploration; MR-TR 2012			
Amer Lake (U)	Uranium North Resources	45 km N of Baker Lake	Exploration; MR-TR 2012			
Nanuq (DMND)	Peregrine Diamonds	170 km N of Chesterfield Inlet	Exploration; MR-TR 2008			
Qilaq (DMND)	Peregrine Diamonds	100 km E of Iqaluit	Exploration; MR-TR 2010			
Aviat (DMND)	Stornoway Diamonds + Hunter[4]	Melville Peninsula	Exploration; CRS 2008			
Seal Zinc (Zn)	Aston Bay Ventures	Aston Bay	Exploration; bulk sampling 2013			
Storm Copper (Cu)	Aston Bay Ventures + Commander Resources	NW Somerset Island	Exploration; TR on exploration history 2013			
Nowyak (Au, Cu, Ag)	Uranium North Resources	245 km W of Arviat	Exploration; drilling in 2011			

Table 10 cont'd. Mine projects in Nunavut under exploration, development or production, that have or will potentially have a marine transportation component. LOM: life of mine; TPY: tonnage per year; Mt: million tonnes; REE: rare earth elements; PEA: Preliminary Economic Assessment; P/D FS: Preliminary/Definitive Feasibility Study; DEIS: Draft Environmental Impact Statement; MR-TR: Mineral Resource-Technical Report; CRS: Conceptual Resource Study; DMND: diamonds; TBD: to be determined.

Project name (mineral)	Company/Proponent	Mine location	Stage	LOM (start yr)	TPY (Mt)	Shipping destination
Mallery Lake (Au)	Uranium North Resources	130 km SW of Baker Lake	Exploration; drilling in 2011			
Atlas-1 (Au, Ag, Cu, Zn)	Anconia Resources	175 km W-NW of Whale Cove	Exploration; drilling in 2013			
Zac (Au, Ag, Cu, Zn)	Anconia Resources	160 km W-NW of Whale Cove	Exploration; drilling in 2013			
Maguse River (Fe)	Ridgemont Iron Ore	60 km N of Arviat	Exploration; drilling in 2011			
Kiyuk Lake (Au)	Prosperity Goldfields	350 km S-SW of Arviat	Exploration; drilling in 2013			
Wishbone (Au, Ag, Cu, Zn, Pb)	Sabina Gold & Silver	140 km S of Bathurst Inlet	Exploration; drilling in 2012			
Agikuni (Au, Cu, Ag)	Uranium North Resources	330 km NW of Arviat	Exploration; drilling in 2010			
Blue Caribou (Au, Cu, Ag)	Mega Precious Metals	480 km NE of Yellowknife	Exploration; MR-TR 2010			
Yathkyed (U)	Uranium North Resources	Kivalliq region, near Angilak	Early exploration			
Baffin Island Gold (Au)	Commander Resources	250 km S of Clyde River	Early exploration			
Cumberland (Ni, Cu, Co, Pt, Au)	Peregrine Diamonds	90 km E of Pangnirtung	Early exploration			
Nanuq North (DMND)	Peregrine Diamonds + Bluestone[3] + Hunter	280 km NE of Baker Lake	Early exploration			

Table 10 cont'd. Mine projects in Nunavut under exploration, development or production, that have or will potentially have a marine transportation component. LOM: life of mine; TPY: tonnage per year; Mt: million tonnes; REE: rare earth elements; PEA: Preliminary Economic Assessment; P/D FS: Preliminary/Definitive Feasibility Study; DEIS: Draft Environmental Impact Statement; MR-TR: Mineral Resource-Technical Report; CRS: Conceptual Resource Study; DMND: diamonds; TBD: to be determined.

Project name (mineral)	Company/Proponent	Mine location	Stage	LOM (start yr)	TPY (Mt)	Shipping destination
North Thelon (U)	Forum Uranium	70 km W of Baker Lake	Early exploration			
Turqavik-Aberdeen (U)	Cameco	85 km W of Baker Lake	Early exploration			
Hammer (DMND)	Stornoway Diamond + North Arrow Minerals	140 km SE of Kugluktuk	Early exploration			
Grail (DMND)	Bluestone Resources	80 km from Taloyoak, Boothia Peninsula	Early exploration			
Borden (DMND)	Bluestone Resources	Western Baffin Island	Early exploration			
Anik (Ni, Cu)	Advanced Exploration	170 km W of Hall Beach	Early exploration			
Southampton (Ni, Co, Cu, Pt, Pd)	Vale Canada	55 km N of Coral Harbour	Early exploration			
Halkett Inlet (Au)	Diamonds North Resources	100 km NW of Kugaaruk	Early exploration			
Amaruk (DMND, Au, Ni)	Diamonds North Resources + MMG Resources	45 km SW of Kugaaruk	Early exploration			
Nunavut Rare Earth (REE)	Cache Exploration	75 km E and 115 km N-NE of Baker Lake	Early exploration			

Table 10 cont'd. Mine projects in Nunavut under exploration, development or production, that have or will potentially have a marine transportation component. LOM: life of mine; TPY: tonnage per year; Mt: million tonnes; REE: rare earth elements; PEA: Preliminary Economic Assessment; P/D FS: Preliminary/Definitive Feasibility Study; DEIS: Draft Environmental Impact Statement; MR-TR: Mineral Resource-Technical Report; CRS: Conceptual Resource Study; DMND: diamonds; TBD: to be determined.

Project name (mineral)	Company/Proponent	Mine location	Stage	LOM (start yr)	TPY (Mt)	Shipping destination
Greyhound Lake (Ag, Au, Cu, Pb, Zn)	Aura Silver Resources	40 km N of Baker Lake	Early exploration			
Peter Lake (Au)	Canada Nickel	40 km NW of Rankin Inlet	Early exploration			
Pistol Bay (Au)	Northquest	35 km NW of Whale Cove	Early exploration			
RB (Au, Ag, Cu, Zn)	Anconia Resources	110 km NW of Whale Cove	Early exploration			
ARNI (Cu, Ni)	Anconia Resources	60 km E of Baker Lake	Early exploration			
Esker (Au)	Diamonds North Resources	180 km NW of Arviat	Early exploration			
Nutaaq (REE)	Forum Uranium	65 km W of Baker Lake	Early exploration			
Oro (Au)	North Arrow Minerals + Sennen Resources	115 km SW of Cambridge Bay	Early exploration			
TAK (DMND)	Shear Diamonds + Rio Tinto Exploration	165 km SE of Kugluktuk	Early exploration			
Coppermine (U)	Hornby Bay Mineral Exploration	100 km S-SW of Kugluktuk	Early exploration			
Turner Lake (Au, Cu, Ni, Pt, Pd)	Northrock Resources	55 km NW of Bathurst Inlet	Early exploration			
Rockinghorse (DMND)	Shear Diamonds Ltd. + Rio Tinto Exploration Canada	165 km SE of Kugluktuk	Early exploration			

[1] AREVA Resources; [2] JCU Exploration; [3] Bluestone Resources; [4] Hunter Exploration Group

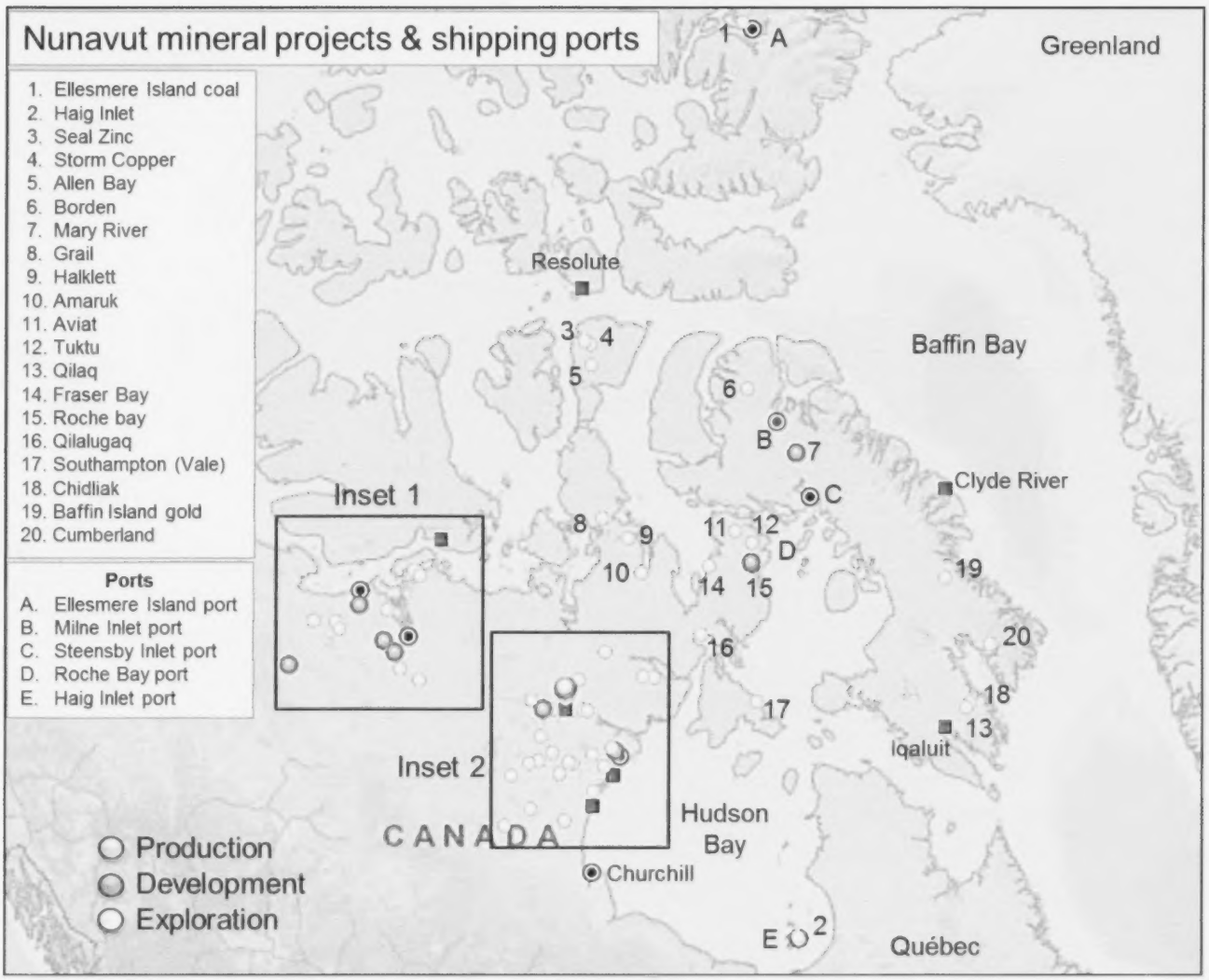


Figure 12. Major mineral projects in Nunavut under exploration, development, or production that have or will potentially have a marine transportation component. Deep-sea ports in northern regions currently in use or to be constructed to service upcoming development are indicated as letters. Details from insets 1 and 2 are shown in Figures 13 and 14.

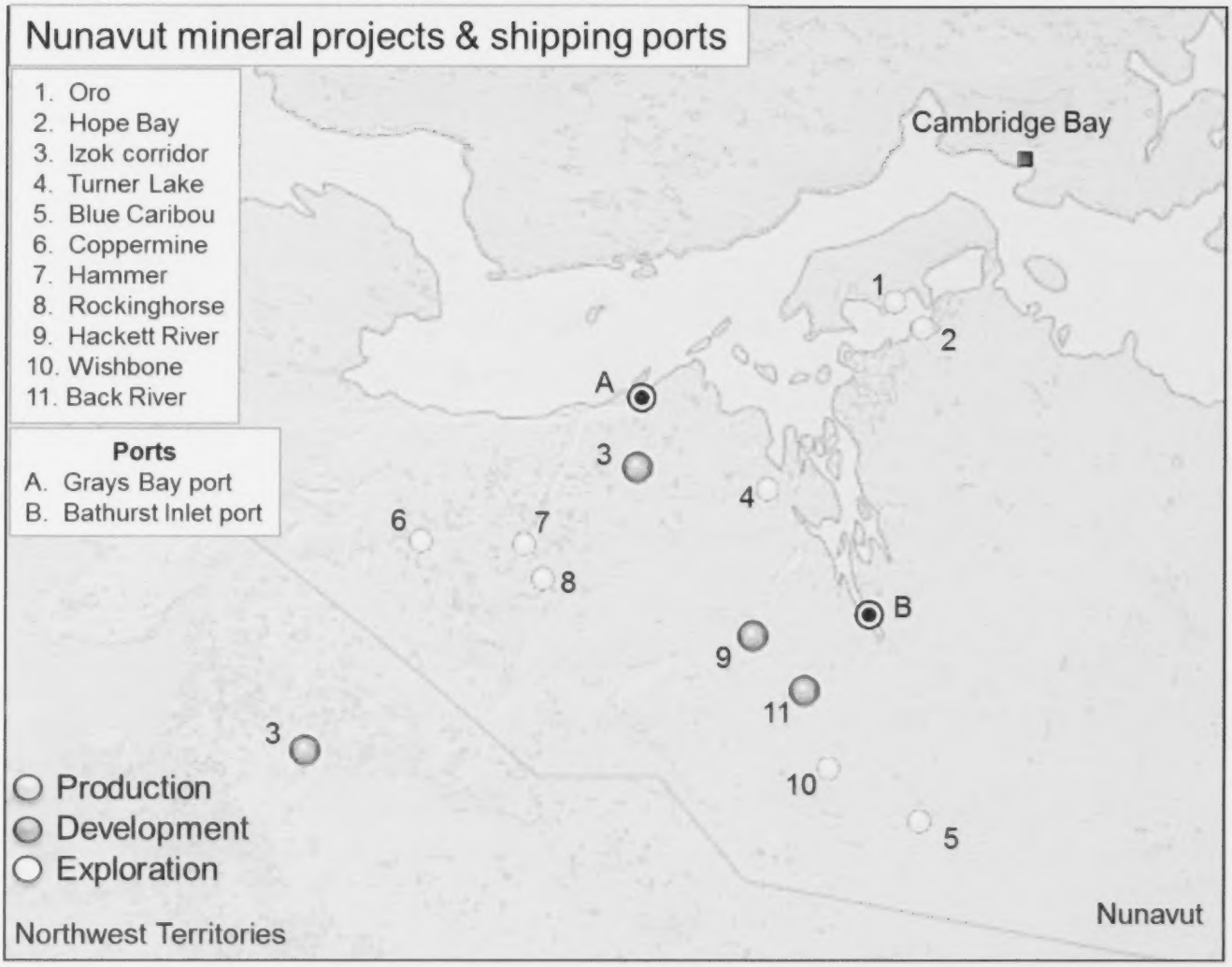


Figure 13. (Inset 1 from Fig. 12) Major mineral projects in Nunavut under exploration, development, or production that have or will potentially have a marine transportation component. Deep-sea ports in northern regions currently in use or to be constructed to service upcoming development are indicated as letters.

Figure 14. (Inset 2 from Fig. 12) Major mineral projects in Nunavut under exploration, development, or production that have or will potentially have a marine transportation component. Deep-sea ports in northern regions currently in use or to be constructed to service upcoming development are indicated as letters.

ONTARIO

Mineral resource development

Currently, there are no mineral developments in Ontario with plans to export ore northerly through Hudson Bay or James Bay. With the exception of two active mines, Ontario's Far North has no major industrial development at present (The Far North Science Advisory Panel 2010). However, significant new mining, processing, and shipping operations are being supported in the "Ring of Fire" mineral district (at least 10 mines are expected to open in northwestern Ontario over the next five years; NOMA 2012). The Ministry of Northern Development and Mines, through the Ring of Fire Secretariat, manages proposed developments, associated environmental assessments, and Aboriginal engagement in the Ring of Fire. Located in the James Bay lowlands approximately 300 km north of the Municipality of Greenstone, current estimates suggest a multi-generational potential for chromite, nickel, copper, and platinum exploitation (www.mndm.gov.on.ca/en/ring-fire-secretariat; accessed 17 January 2013). Major development in northern Ontario might incent industry to eventually use marine transport routes through Hudson Bay and James Bay and then to markets (*The New Deal for Northern Ontario* www.newdealnorth.ca; accessed 17 January 2013).

MANITOBA

Mineral resource development

Currently, there is no mineral export planned towards Manitoba ports on Hudson Bay. However, the province is working with partners to develop and promote the Arctic Gateway transportation corridor, an international Arctic shipping route connecting Churchill to the Port of Murmansk, Russia. The port of Churchill, Canada's only International Arctic seaport, is strategically positioned to service many Arctic communities and to provide reduced shipping distances to global markets. Under Manitoba's *Northern Development Strategy*, preliminary studies are underway to examine the feasibility of a road from Gillam, MB, to Churchill and to Nunavut (www.gov.mb.ca/ana/info/nds.html; accessed 18 January 2013). This would link mineral developments in both northern Manitoba and in southern Nunavut to the port of Churchill. Churchill also provides the Prairie Provinces with a shorter route to European markets compared to the Great Lakes and St. Lawrence River ports. Oil producers in Alberta and Saskatchewan are progressively assessing use of the port of Churchill for export, especially as the uncertainty of pipeline construction grows, and may begin to ship heavy oil to Churchill as early as 2013 (Cattaneo 2012). There is also a heavy rail link from Thompson, MB, to the port of Churchill, which may become an appealing transport option for mining developments in the Thompson region (Manitoba Prospectors and Developers Association Inc. 2012).

NORTHWEST TERRITORIES

Shipping in the Northwest Territories has largely been in the form of barges carrying fuel, bulk commodities, and large cargo from Hay River or Port Simpson through Great Slave Lake and up the Mackenzie River to the High Arctic and the port of Tuktoyaktuk, NWT (Government of Yukon 2008). The Government of the Northwest Territories is currently revising the option of expanding this marine transport route to take advantage of a reduced sea-ice cover and longer shipping season. This transport route would use the port of Tuktoyaktuk on the Beaufort Sea coast and the Mackenzie River as the entry point to supply the Mackenzie Gas Project and potentially to move heavy equipment to the Alberta oil sands (Government of Yukon 2008). An all-weather highway from Inuvik, NWT, to Tuktoyaktuk has just received funding from the Government of Canada and should soon proceed with construction. This road link will provide year-round overland access to the Arctic coast, which will support Canada's sovereignty interests, improve capabilities for search and rescue, and enhance economic opportunities (Infrastructure Canada 2013).

Mineral resource development

The Northwest Territories presently has four producing mines (three diamond mines and one tungsten mine) and seven significant mineral projects in various stages of development expected to enter production between 2015 and 2017 (Government of the Northwest Territories 2013). The current transport scheme for most mines in northern regions is southward via road or rail. A winter road, linking Tibbitt Lake, NWT (60 km E of Yellowknife) to Contwoyto Lake (Kitikmeot Region of Nunavut, 200 km SW of Bathurst Inlet), is constructed every year and operates for approximately three to five months per year beginning in December. If the Bathurst Port and Road Project (currently under review by the NIRB) is granted approval and moves into construction, this will open a new transport corridor for mine developments in northern regions of the Northwest Territories to this new port in Nunavut, with potential for year-round shipping out of the Coronation Gulf. AANDC has developed an online mapping tool called the NT GeoViewer to display the location and details pertaining to mineral tenure and developing projects in the Northwest Territories (www.aadnc-aandc.gc.ca/eng/1100100023768/1100100023772; accessed 10 February 2013).

Oil and gas development: Mackenzie Delta/Beaufort Sea

The Beaufort Sea and Mackenzie Delta of the Northwest Territories is a region particularly rich in petroleum resources. Around 60 discoveries have been made to date, although there remains high potential for unidentified oil and gas fields in vast undrilled geological structures, particularly offshore (AANDC 2013a).

Historic oil and gas exploration activities began in the Mackenzie Delta/Beaufort Sea onshore region in 1957 with reconnaissance-type land and aerial surveys. The first exploratory drilling operation was completed in 1961 in the Mackenzie Delta and in 1970, Imperial Oil reported the first discovery of oil in the Mackenzie Delta at Atkinson Point. This followed with the discovery of major gas fields at Taglu (1971), Parsons Lake (Gulf; 1972) and Niglintgak (Shell; 1973). This led to the proposed Mackenzie Valley Pipeline in 1974, and augmented exploration and investment offshore to locate new fields (Callow 2013). However, with the decline of global oil prices and demand in the mid-1980s, oil and gas exploration in the western Canadian Arctic was impacted due to limited financing. In March 1989, the Exxon Valdez struck bottom in Prince William Sound, Alaska, resulting in one of the world's largest oil spills (NOAA 2013). This had repercussions on oil and gas exploration, development, and transportation throughout North America, particularly in the Beaufort Sea, as stricter regulations for oil spill prevention were imposed by the U.S. Congress, Environment Canada and the NEB (Sylves 1998). More recently, oil and gas activity in the Canadian Arctic was again decelerated following to the BP Deepwater Horizon oil spill in the Gulf of Mexico, USA. in 2010. This prompted the NEB to undertake a major Arctic Offshore Drilling Review to evaluate hazards, risks, and safety measures associated with offshore drilling in the Canadian Arctic (NEB 2011b). Industry still has strong interest in the Mackenzie Delta/Beaufort Sea region, which is known to hold significant hydrocarbon reserves as well as a high potential of undiscovered fields (Drummond 2009). There are also large offshore areas of the Beaufort Sea that are sparsely explored and have the potential for major oil and gas discoveries (Morrell 2007). A number of studies have attempted to predict future oil and gas development in the Mackenzie Delta/Beaufort Sea region (GLJ 2004, Morrell 2005, Morrell 2007, Integrated Environments Ltd 2011). A study released in 2012 and updated in 2013, compiled all available information provided by the oil and gas industry and predicted an increase in seismic activity and well drilling over the next 15 years in the Beaufort Sea (Table 11; Callow 2013). Any long-term prediction of oil and gas activities in the Beaufort Sea will invariably have a large margin for error (Callow 2013).

The number of current exploration licences in the Beaufort Sea and the associated financial and well drilling commitments they hold is an indication of future oil and gas activity in this region (Table 12). As of May 2013, the Beaufort Sea contained 17 exploration licences that have expiry dates ranging from 2015 to 2022, depending on when the nine-year licence was issued. There are 38 significant discovery licences in the Beaufort Sea and no production licences. There are currently five exploration licences in the Mackenzie Delta, expiring between 2017 and 2020, and two production licences expiring in 2024 and 2033. One production licence (Ikhil gas field; PL06; Atlas Gas Ltd) has been under commercial production since 2000 and gas is delivered through a 50 km pipeline to Inuvik. The second production licence (PL25; MCM Energy Corp.) was issued in 2008 and is not currently producing. Thirty-eight significant discoveries have been made in the Mackenzie Delta region (Fig. 15; AANDC 2012b). In October 2013, the Minister of Indian Affairs and Northern Development launched a call for the submission of bids for one parcel (covering approximately 47,945 hectares) in the Beaufort Sea of the Northwest Territories (AANDC 2013b). The successful bidder, chosen on the basis of the total amount of money proposed, will be announced in spring of 2014. The following paragraphs list active or proposed oil and gas projects within the Mackenzie Delta/Beaufort Sea region:

The Mackenzie Gas Project (MGP) aims at developing natural gas fields in the Mackenzie Delta of the Northwest Territories and delivering the natural gas to markets through a pipeline system built along the Mackenzie Valley. Three major gas fields in the Mackenzie Delta would be exploited for the project (Taglu, Parsons Lake, and Niglintgak; www.mackenziegasproject.com/theProject/index.html; accessed 12 January 2013). Four major Canadian oil and gas companies (Imperial Oil Resources Ventures Ltd, ConocoPhillips Canada Ltd, Shell Canada Ltd, ExxonMobil Canada) and The Aboriginal Pipeline Group are partners in the project. The MGP received NEB approval and a Certificate of Public Convenience and Necessity in March 2011. The approval contained 264 conditions, including the requirement to submit an updated cost estimate and report on the decision to construct by the end of 2013, and that construction must commence by 31 December 2015, otherwise the project will need to go through another NEB review. Given the poor market conditions, Imperial Oil announced in December 2013 that it does not foresee continuing the MGP in the immediate future (Jones 2013). If the project were to be revived, the estimated cargo required for the project is approximately 1.2 Mt, notably for facility, infrastructure, drilling, and construction requirements. Most cargo will be transported by barge from Hay River, NWT. The movement of offshore modules for the anchor fields and the Inuvik area facility will require several trips into and out of the Mackenzie Delta. Over its lifetime, the MGP could see a sequence of tie-ins from existing significant discoveries and potential new discoveries in the Mackenzie Delta and Beaufort Sea. For instance, a total of 11 onshore and 10 offshore existing significant discoveries could potentially be connected to the pipeline system. However, Imperial Oil and Exxon Mobil have recently announced their consideration of a more cost-effective strategy by transforming the MGP into a liquefied natural gas (LNG) development. LNG may become a valuable upcoming opportunity for Canada's energy sector if international prices favor development of the country's considerable shale gas reserves.

There is currently a large initiative to acquire regional baseline environmental and geological information and fill knowledge gaps on oil and gas reserves in the Mackenzie Delta/Beaufort Sea region. For example, the Environmental Studies Research Funds (ESRF), the Program of Energy Research and Development (PERD) and the Beaufort Regional Environmental Assessment (BREA) all fund environmental and socio-cultural studies related to oil and gas exploration and development on Canada's frontier lands. Research efforts such as the BREA which includes 14 ongoing research projects, nine completed projects, and six working groups, are working towards a database to support responsible resource development in the Beaufort Sea. This is a multi-year (2011–2015) and multi-faceted regional research initiative to make historical information available and build a modern database to inform regulatory processes and project-specific environmental assessments related to oil and gas activity in the Beaufort Sea area. The program is led by AANDC, Canadian Association of Petroleum Producers, Inuvialuit Game Council, and Inuvialuit Regional Corporation (www.beaufortrea.ca; Accessed 15 May 2013).

Seismic exploration of the subsurface structure is currently being employed to create a modern seismic picture of the Beaufort Sea region and to assess potential for future drilling in licence areas. For instance, the Geological Survey of Canada and the Korea Polar Research Institute carried out a major Canada-Korea-USA Beaufort Sea Geoscience Research Program in late 2013. The program involved geophysical surveys (2D seismic surveys), geologic sampling, and oceanographic measurements in the Beaufort Sea. The program operated in water depths

ranging from 30 to 2000 m, while 2D seismic data acquisition occurred in water depths ranging from 50 to 2000 m (Kavik-Stantec Inc. and The Geological Survey of Canada 2012).

In December 2012, Imperial Oil Resources Ventures Ltd, ExxonMobil Canada Ltd, and BP Exploration Operating Company Ltd filed a filed a Preliminary Information Package on behalf of the Beaufort Sea Exploration Joint Venture. The package outlines a major offshore drilling program on EL476 (Ajurak) and EL477 (Pokak) exploration licences (ELs) in the Beaufort Sea (Imperial Oil Resources Ventures Ltd 2012). These ELs are in the Canadian Beaufort Sea approximately 125 km north-northwest of Tuktoyaktuk (Inuvik Region of the Northwest Territories) in water depths ranging from 60 to 1500 m. A typical well-drilling operation could extend over three or more summer seasons. Imperial estimates that the regulatory process and approval from the NEB could be completed as early as 2015. The offshore drilling operation would require a drilling rig and related equipment, marine support vessels (ice-class supply vessels, icebreaking support vessels), emergency and spill response vessels and equipment, a double-hulled ice-class fuel tanker to meet fuel requirements for an entire drilling season, and a shore-based facility, likely in Tuktoyaktuk, with a warebarge or ware ship. Several other shore-based facilities and services to support the offshore drilling program are detailed in the Preliminary Information Package (Imperial Oil Resources Ventures Ltd 2012, Callow 2013). In September 2013, Imperial Oil submitted a Project Description of the Beaufort Sea drilling program to the Environmental Impact Screening Committee of the NEB (Imperial Oil Resources Ventures Ltd 2013). If approval from the governing authorities is granted and if the economy is favorable, the project foresees a drilling schedule beginning in 2020.

Franklin Petroleum Ltd was granted eight exploration licences in the Beaufort Sea during the 2011–2012 Beaufort Sea and Mackenzie Delta Call for Bids regulated by AANDC. The company submitted a project proposal to the Environmental Impact Screening Committee in January 2013 to conduct a seismic program during the open-water period of 2013 (between the last week of July and mid-October), or during subsequent years of their lease term. The primary objective was to acquire 2D and/or 3D seismic data over their exploration licences (Upun-LGL 2013; Franklin Petroleum Ltd 2013). Future operations will likely include more seismic surveys and eventually application for a drilling program.

In summary, historical predictions of oil and gas activity in the Mackenzie Delta/Beaufort Sea foresaw natural gas exploitation from the MGP as the dominate hydrocarbon development. However, since the MGP has recently been considered unfeasible for economic reasons, industry has shifted focus to oil development in the Mackenzie Delta/Beaufort Sea. If oil extraction should proceed in the Beaufort Sea, it will not necessarily require construction of a pipeline network from offshore rigs to onshore; alternatives include gravity-based structures or floating production storage and offloading facilities to temporarily store oil until it can be offloaded to a tanker or transport to the mainland. Given the very early stage of oil development in the Beaufort Sea region, it is difficult to predict which oil production systems would be used (Callow 2013).

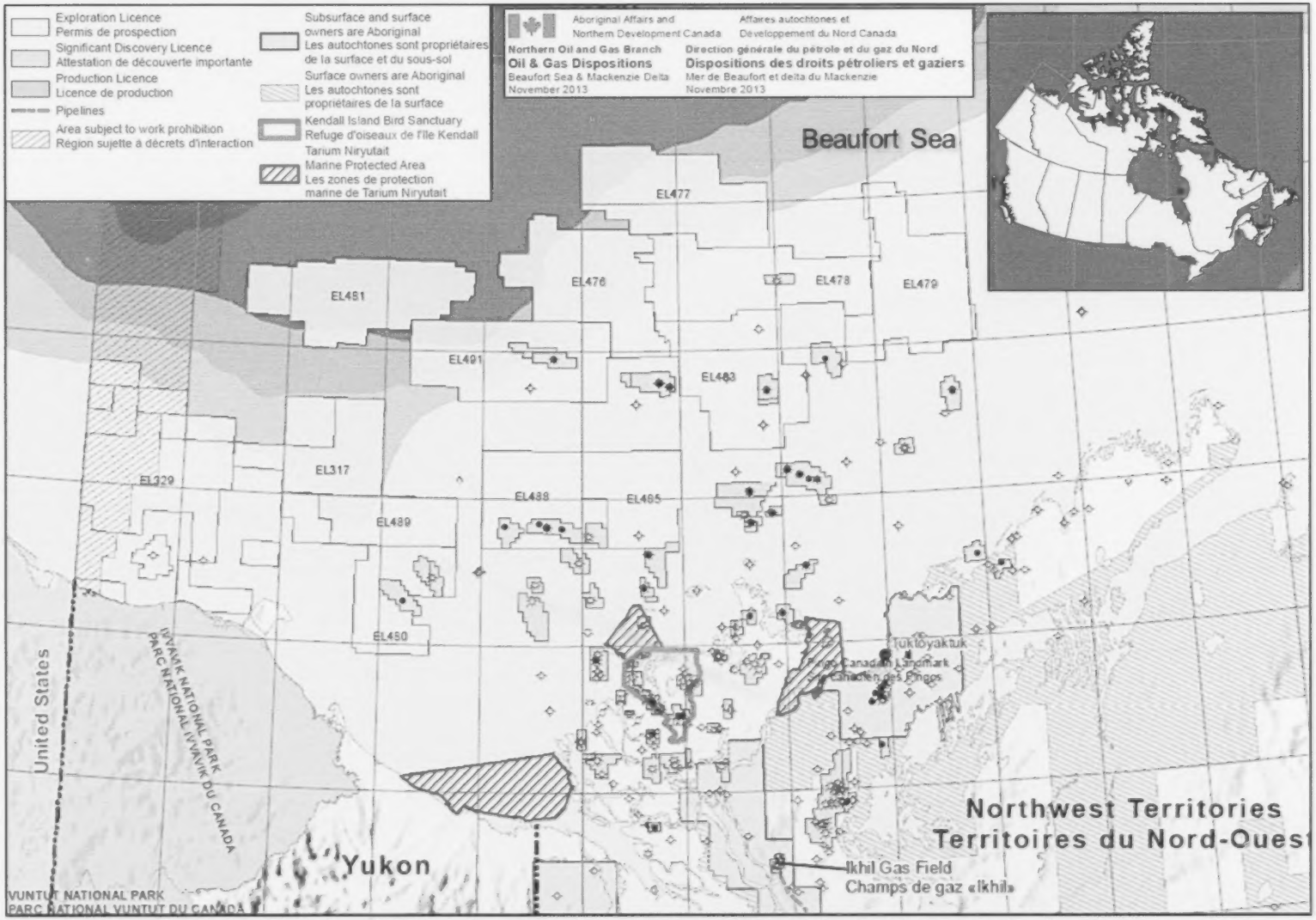


Figure 15. Beaufort Sea and Mackenzie Delta oil and gas dispositions as of November 2013: Exploration licences (pale yellow); significant discovery licences (pink); production licence (blue) (map available online from www.aadnc-aandc.gc.ca/eng/1100100036207/1100100036257; Accessed 31 December 2013; reproduced with permission from AANDC).

Table 11. Potential offshore oil and gas exploration and development activities in the Mackenzie Delta/Beaufort Sea region from 2013 to 2027 (Callow 2013). EL: exploration licence; MGP: Mackenzie Gas Project.

Activity	Predicted timing or intensity
2D Seismic Surveys	Sporadic; 1 or 2 per year
3D Seismic Surveys	On each EL a few years prior to drilling
Wellsite Seismic Surveys	Prior to drilling the identified well(s)
Mackenzie Gas Project	Possible start-up delayed beyond 2023
Discovered Offshore Gas tie-ins to MGP	None over the next 15 years
Shallow Shelf Exploration Wells	1 or 2 per year starting in 2016
Deep Shelf and Slope Exploration Wells	First well 2020, 2–3 more wells by 2028
Shallow Shelf Oil Production	First potential drilling/construction 2020
Oil Production from the Beaufort Sea	Potentially beginning in 2025

Table 12. Current oil and gas exploration, significant discovery and production licences in the Beaufort Sea and Mackenzie Delta, to be used in conjunction with Figure 15 (AANDC 2012c). EL: exploration licence; SDL: significant discovery licence; PL: production licence.

Licence #	Area (ha)	Representative	Effective date	Well to be drilled	Expiry date
EL456	73,391	MGM Energy Corp.	05-Jan-2011	04-Jan-2016	04-Jan-2020
EL457	67,284	MGM Energy Corp.	05-Jan-2011	04-Jan-2016	04-Jan-2020
EL458	75,244	MGM Energy Corp.	05-Jan-2011	04-Jan-2016	04-Jan-2020
EL459	74,618	MGM Energy Corp.	05-Jan-2011	04-Jan-2016	04-Jan-2020
EL460	205,946	Chevron Canada Ltd.	05-Jan-2011	04-Jan-2016	04-Jan-2020
EL476	205,321	Imperial Oil Resources Ventures	01-Sept-2012	31-Jul-2017	31-July-2019
EL477	202,380	Imperial Oil Resources Ventures	01-Sept-2012	30-Sep-2018	30-Sept-2020
EL478	205,359	BP Exploration Co. Ltd.	01-Sept-2012	30-Sep-2018	30-Sep-2020

Table 12 cont'd. Current oil and gas exploration, significant discovery and production licences in the Beaufort Sea and Mackenzie Delta, to be used in conjunction with Figure 15 (AANDC 2012c). EL: exploration licence; SDL: significant discovery licence; PL: production licence.

Licence #	Area (ha)	Representative	Effective date	Well to be drilled	Expiry date
EL479	203,635	BP Exploration Co. Ltd.	01-Sept-2012	30-Sep-2018	30-Sept-2020
EL480	108,185	Chevron Canada Ltd	01-Sept-2012	31-Oct-2015	31-Oct-2019
EL481	205,946	Chevron Canada Ltd.	01-Sept-2012	31-Aug-2019	31-Aug-2021
EL482	103,711	ConocoPhillips Canada Resources	29-Aug-2012	28-Jun-2015	28-June-2019
EL483	196,497	ConocoPhillips Canada Resources	01-Sept-2012	30-Sep-2018	30-Sept-2020
EL484	90,381	Franklin Petroleum	01-Sept-2012	31-Aug-2017	31-Aug-2021
EL485	120,314	Franklin Petroleum	01-Sept-2012	31-Aug-2019	31-Aug-2021
EL488	134,142	Franklin Petroleum	06-Mar-2013	5-Mar-2020	05-Mar-2022
EL489	93,483	Franklin Petroleum	06-Mar-2013	5-Mar-2018	05-Mar-2022
EL490	99,324	Franklin Petroleum	06-Mar-2013	5-Mar-2018	05-Mar-2022
EL491	201,101	Franklin Petroleum	06-Mar-2013	5-Mar-2020	05-Mar-2022
EL492	187,200	Franklin Petroleum	06-Mar-2013	5-Mar-2020	05-Mar-2022
EL493	190,650	Franklin Petroleum	06-Mar-2013	5-Mar-2020	05-Mar-2022
PL06	2,506	AltaGas Ltd.	23-Jun-1999		22-Jun-2024
PL25	917	MGM Energy Corp.	17-Sep-2008		16-Sep-2033
SDL014 –016	2,738	Chevron Canada Ltd.	05-Sep-1987		
SDL017 –019	8,897	Shell Canada Ltd.	18-Aug-1987		
SDL025 –028	4,843	Nytis Exploration Co. Canada Ltd.	09-Feb-1988		
SDL029	3,132	AltaGas Ltd.	01-Sep-1987		

Table 12 cont'd. Current oil and gas exploration, significant discovery and production licences in the Beaufort Sea and Mackenzie Delta, to be used in conjunction with Figure 15 (AANDC 2012c). EL: exploration licence; SDL: significant discovery licence; PL: production licence.

Licence #	Area (ha)	Representative	Effective date	Well to be drilled	Expiry date
SDL029	3,132	AltaGas Ltd.	01-Sep-1987		
SDL030	2,173	ConocoPhillips Canada Ltd.	17-Jun-1987		
SDL031	306	Shell Canada Ltd.	17-Jun-1987		
SDL032	30,117	ConocoPhillips Canada Ltd.	17-Jun-1987		
SDL033 –036	8,607	Shell Canada Ltd.	17-06-1987		
SDL037	8,034	BP Canada Energy Resources Co.	24-Sep-1987		
SDL038 –041	34,051	BP Canada Energy Resources Co.	12-Aug-1987		
SDL047 –049	13,471	BP Canada Energy Resources Co.	21-Aug-1987		
SDL050 –065	65,347	Imperial Oil Resources Ltd.	22-Apr-1987		
SDL083 –088	42,518	ConocoPhillips Canada Resources	22-Feb-1989		
SDL089	10,512	BP Canada Energy Co.	13-Nov-1989		
SDL091 –095	25,523	Imperial Oil Resources Ltd.	04-May-1990		
SDL096 –097	1,412	ConocoPhillips Canada Resources	19-Jul-1990		
SDL100	2,763	Shell Canada Ltd.	29-Nov-1990		
SDL110 –112	3,267	Imperial Oil Resources Ltd.	30-Jan-1992		
SDL113 –114	9,582	BP Canada Energy Resources Co.	25-Mar-1993		
SDL115	3,000	Imperial Oil Resources Ltd.	11-Jul-1994		
SDL116	2,700	Imperial Oil Resources Ltd.	10-Jun-1998		
SDL126	16,618	ConocoPhillips Canada Resources Corp.	01-Aug-2005		

Table 12 cont'd. Current oil and gas exploration, significant discovery and production licences in the Beaufort Sea and Mackenzie Delta, to be used in conjunction with Figure 15 (AANDC 2012c). EL: exploration licence; SDL: significant discovery licence; PL: production licence.

Licence #	Area (ha)	Representative	Effective date	Well to be drilled	Expiry date
SDL130	14,458	Devon NEC Corp.	26-Apr-2007		
SDL132 –135	4,286	MGM Energy Corp.	13-Nov-2007		
SDL136	924	MGM Energy Corp.	17-Jan-2008		
SDL144	5,862	Suncor Energy Inc.	16-Sep-2008		
SDL146	7,090	MGM Energy Corp.	23-Apr-2009		

YUKON

Mineral resource development

Yukon currently has three producing mines and several additional projects in various stages of exploration and development; however, no project involves export to ports in northern Yukon (Pigage et al. 2013). In fact, there are no communities or marine infrastructure on the northern Yukon coastline. Mineral export to foreign markets relies on established marine transportation networks via ports in Alaska, such as Skagway and Haines, or the ports of Prince Rupert and Stewart in British Columbia. There has been interest in the development of a deep-sea Arctic port at King Point on the north coast of Yukon to provide strategic access to the Beaufort Sea and marine trade routes (Government of Yukon 2008). However, short shipping seasons (ca. 100 days per year) and the expenditure required to build port facilities currently present important barriers to development (KPMG LLP 2006).

EASTERN ARCTIC OFFSHORE

Oil and gas development

The Eastern Arctic offshore region includes Baffin Bay, Davis Strait, Hudson Bay (north of 60°N), and Foxe Basin. It is estimated that 55% of the potential for oil and gas lies north of 60°N, with 48% in the Hudson Bay Basin, and 7% in the Foxe Basin (Drummond 2009). There are several historical exploratory permits (issued under the former Canada Oil and Gas Regulations) in the Eastern Arctic, mainly in Lancaster Sound, and south of Coat's Island and Southampton Island in the northern Hudson Bay Basin (Fig. 16). However, as they stand, they do not provide any rights to the holder like exploration licences. There has been very little past exploration in this area, although one significant discovery was made in the Baffin Bay area (Hekja 0-71), located on the southeast Baffin Shelf in the Davis Strait within the Saglek Basin. This region is believed to have high hydrocarbon potential and may see a growing interest in future years, given the increase in exploration efforts on the Greenland side of Baffin Bay (Bureau of Minerals and Petroleum 2011). Hudson Bay has also seen very little historical seismic survey work, with only five wells drilled in the centre of the basin, resulting in a poor understanding of oil and gas reserves. No seismic work has been conducted within Foxe Basin (Frampton 2012). There is currently one application submitted before the NEB proposing a five-year offshore marine 2D seismic reflection survey in Baffin Bay and Davis Strait (Multi Klient Invest AS 2011).

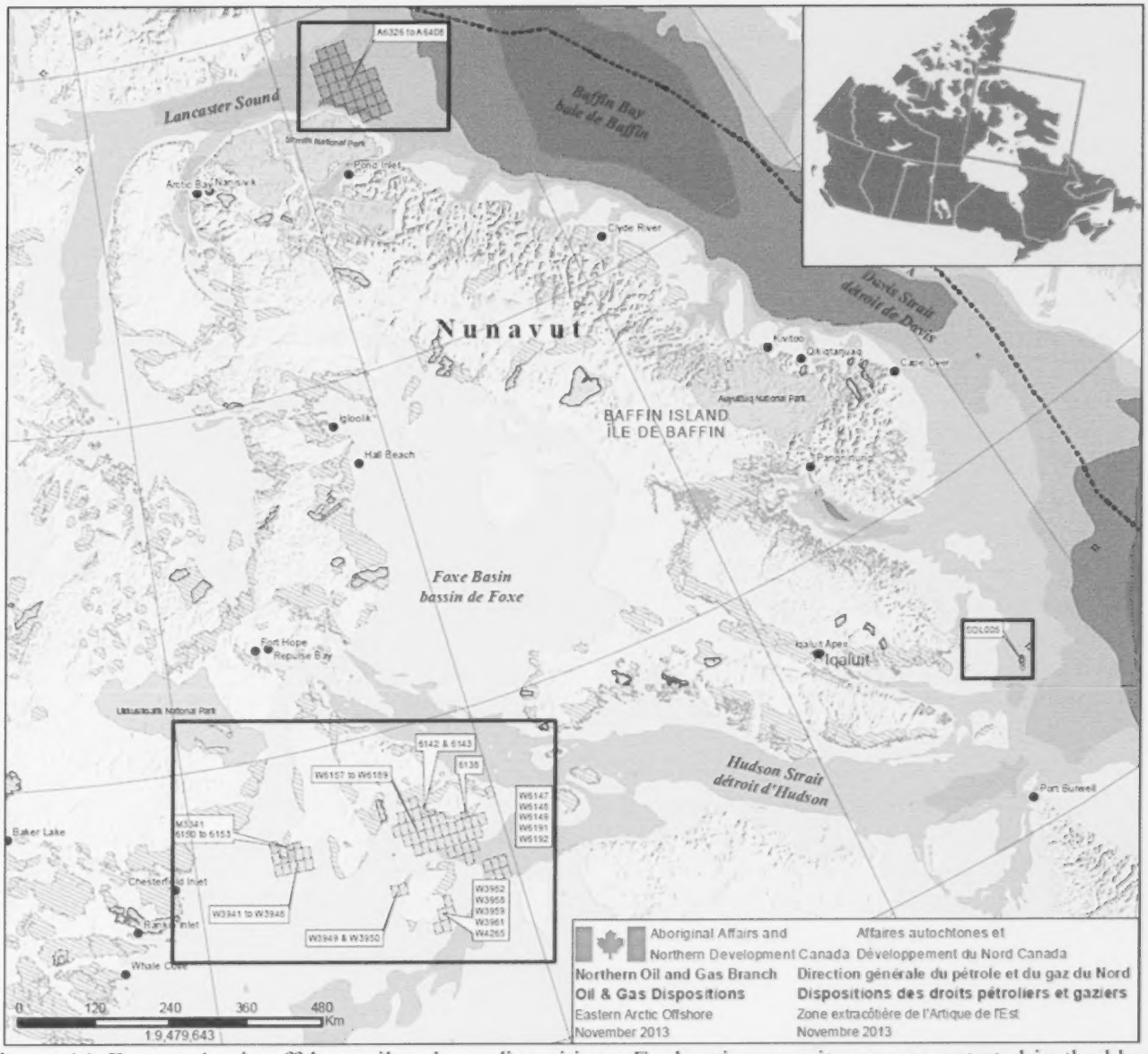


Figure 16. Eastern Arctic offshore oil and gas dispositions. Exploration permits are concentrated in the black boxes, primarily around Southampton Island, Coats Island, and Lancaster Sound. One significant discovery licence has been issued off the southeast coast of Baffin Island, also black-boxed. No production licences have been issued (map and additional information on permit holders available online from www.aadnc-aandc.gc.ca/eng/1100100036273/1100100036296; Accessed 31 December 2013; reproduced with permission from AANDC).

HIGH ARCTIC OFFSHORE

Oil and gas development

The Arctic Islands basin in the High Arctic is divided between the Northwest Territories and Nunavut. Several significant discoveries have been made within the Arctic Islands, notably within Sverdrup Basin (Fig. 17). Exploratory drilling in the 1970s and 80s revealed significant petroleum discoveries on or near every major island in the western Sverdrup Basin (Frampton 2012). Of the 180 wells that have been drilled in the Arctic Islands, 140 were drilled in Sverdrup Basin and in the adjacent Franklinian Geosyncline basins. Of these 140 wells, every second well flowed with petroleum and one out of five flowed oil. In comparison, this represents more petroleum discovered per unit effort than in the western provinces of Canada, i.e., Alberta and Saskatchewan (Frampton 2012). Two of the largest undeveloped gas fields in Canada are in the Arctic Islands (Northern Oil and Gas Directorate; Indian and Northern Affairs Canada 1995). Melville Island's significant gas fields have been studied for development feasibility by several different companies over the past four decades (CERI 2004, CERI 2005, Frampton 2012). However, costs and logistics to produce and deliver oil and gas from the High Arctic is currently a major hurdle to development. Melville Island, Lougheed Island, and Cameron Island are known large resources of petroleum that could be producing in 10 years, given favourable markets (Frampton 2012).

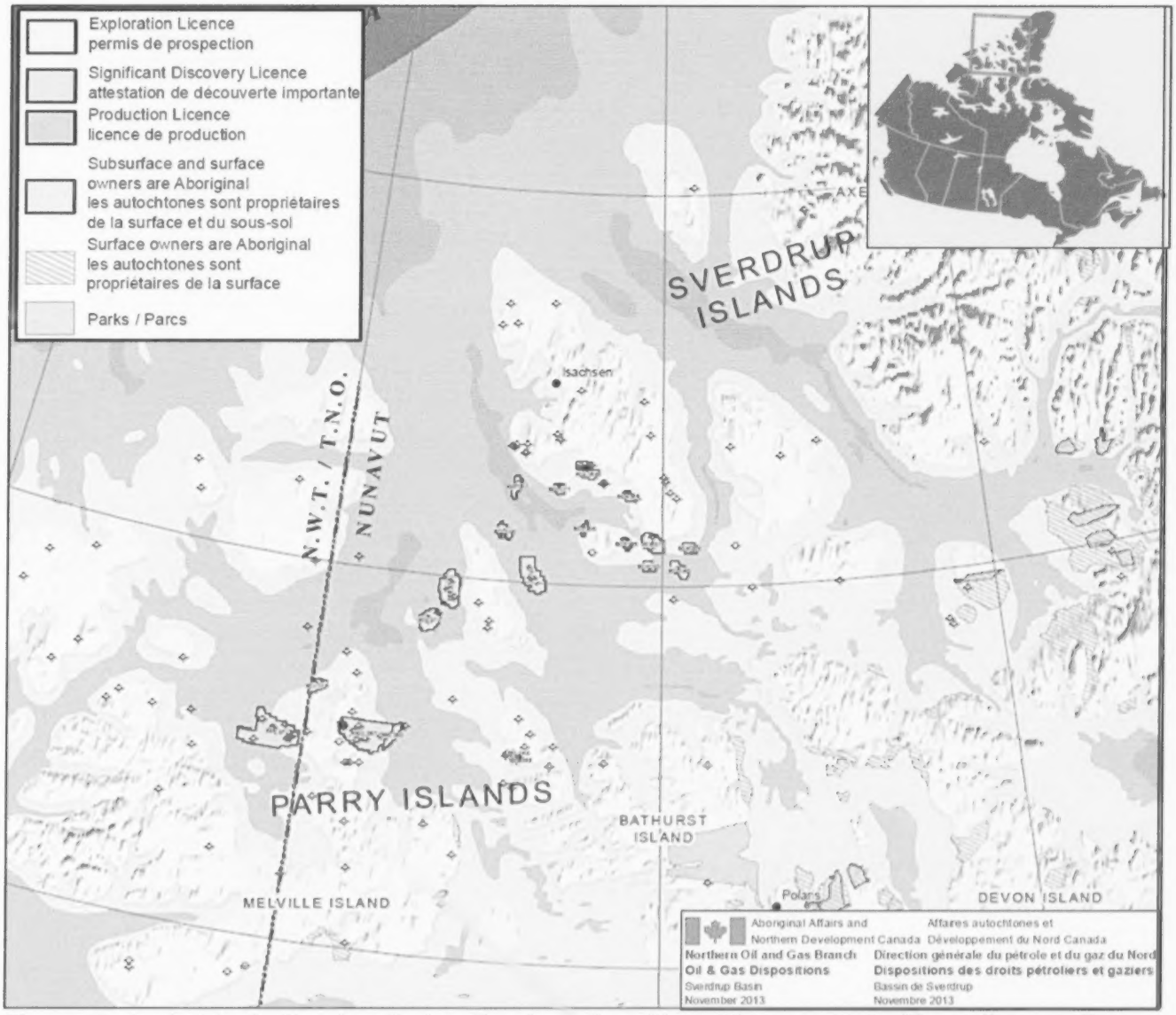


Figure 17. Arctic Islands (Sverdrup Basin) oil and gas dispositions. There are 20 significant discovery licences (pink) and no production licences (map and additional information on licence holders available online from www.aadnc-aandc.gc.ca/eng/1100100036273/1100100036296; Accessed 31 December 2013; reproduced with permission from AANDC).

INFRASTRUCTURE

The following section includes planned infrastructure projects in Canada's North that are not directly related to mineral or oil and gas development.

An Arctic/Offshore Patrol Ship Project has recently been established by the Government of Canada in order to assert and enforce sovereignty in Canadian waters. This project involves the construction of six to eight Arctic Offshore Patrol Ships (Polar Class 5), which are capable of conducting operations in ice during the summer months. Delivery of the first ship is planned for 2018, and all ships are expected to be fully operational in 2023 (National Defence and the Canadian Armed Forces 2013).

The Department of National Defence of the Government of Canada is planning to build a Naval Facility in Nanisivik, Nunavut, located approximately 33 km northeast of the hamlet of Arctic Bay, in the North Baffin region (Government of Canada 2009b). The facility will be strategically placed for access to the Northwest Passage. The primary objective of the Naval Facility will be to provide a mooring and refueling facility for government vessels such as Arctic Offshore Patrol Ships and the Canadian Coast Guard during the navigable season (June through October) each year. The facility may also serve as a logistics centre for cargo and goods from commercial vessels and could provide shelter, work areas and amenities for personnel. The construction is proposed to begin in 2014 and full operation is expected for 2016 (Stantec Consulting Ltd 2013).

A new Canadian Forces Arctic Training Centre in Resolute Bay, Nunavut, has been proposed. However the Canadian army has been recently faced with a 22% budget cut, which will have a negative impact on the development of this High Arctic Training Centre (Nunatsiaq News 2013). If the project eventually proceeds, the centre will be a multi-purpose facility to provide specialized training in cold weather survival and military operations and training, search and rescue techniques, and Canadian Ranger training (Government of Canada 2009a).

The Government of Canada is overseeing construction of the Canadian High Arctic Research Station in Cambridge Bay, Nunavut. The Research Station will be a world-class, year-round, multidisciplinary facility exploring cutting-edge Arctic science and technology issues. Cambridge Bay will soon become the regional hub for Arctic research activities in Canada's North. The station is expected to be fully operational by 2018 (Minister of Aboriginal Affairs and Northern Development 2011).

Under the *Northern Strategy* of Canada's Economic Action Plan, the construction of a small craft harbour in Pangnirtung, Nunavut, was completed in 2013 (DFO 2013). The goal of this project is to provide expanded harbour infrastructure to accommodate commercial fisheries while also serving other marine-related interests of the community, including annual sealift. This is the first small craft harbour in Nunavut and consists of several components, including a fixed wharf, breakwater, marshalling area, sealift ramp, and a dredged channel and basin (Government of Canada 2009b).

Nalcor Energy is proposing a major Lower Churchill hydroelectric power project. The project consists of two main phases of construction: Muskrat Falls and the Labrador-Island Transmission Link, which will deliver electricity produced at the Muskrat Falls hydroelectric generating facility the island of Newfoundland. This will include a 35 km subsea cable crossing from Forteau Point, Labrador, across the Strait of Belle Isle to Shoal Cove, Newfoundland. On November 26, 2013, the Government of Canada released the Labrador-Island Transmission Link from environmental assessment (Nalcor Energy 2013). It should take approximately three years to complete the underwater cable crossing. Construction on the Muskrat Falls Project will take five years, with first produced power expected in 2017 (http://nalcorenergy.com/reviews-assessments.asp; accessed 13 January 2013).

Arctic Fibre is proposing a fibre optic telecommunications system project, one of the largest submarine cable systems in the world (Fig. 18). The network would connect Asia to Western Europe via the southern channel of the Northwest Passage in the Canadian Arctic. The project would require the installment of a 15,600 km subsea fibre optic cable spanning between Maruyama, Japan, and Cornwall, England, via the Bering Strait, Beaufort Sea, and Canadian Arctic. Installing the underwater cable would require three ships: one starting from Japan, a second one departing from England, and a third one for northern Canadian waters (Arctic Fibre 2013). Phase 1 of the project would involve a primary network with cable landings at the following locations: Cambridge Bay, Gjoa Haven, Boothia Peninsula West (Taloyoak), Boothia Peninsula East (Felix Harbour), Igloolik, Hall Beach, Cape Dorset, and Iqaluit in Nunavut, at Deception Bay (Nunavik) and near Fort George (west of Chisasibi), Quebec (Fig. 18). Phase 2 of the project would be to extend secondary branches from the main backbone to service northern coastal communities on both the western and eastern shores of Hudson Bay, around Ungava Bay, as well as the eastern shore of Baffin Island. Some of the secondary routes will depend on external funding. The construction of the primary network is planned for May 2014 and scheduled to be in service by January 2016 (Arctic Fibre 2013).

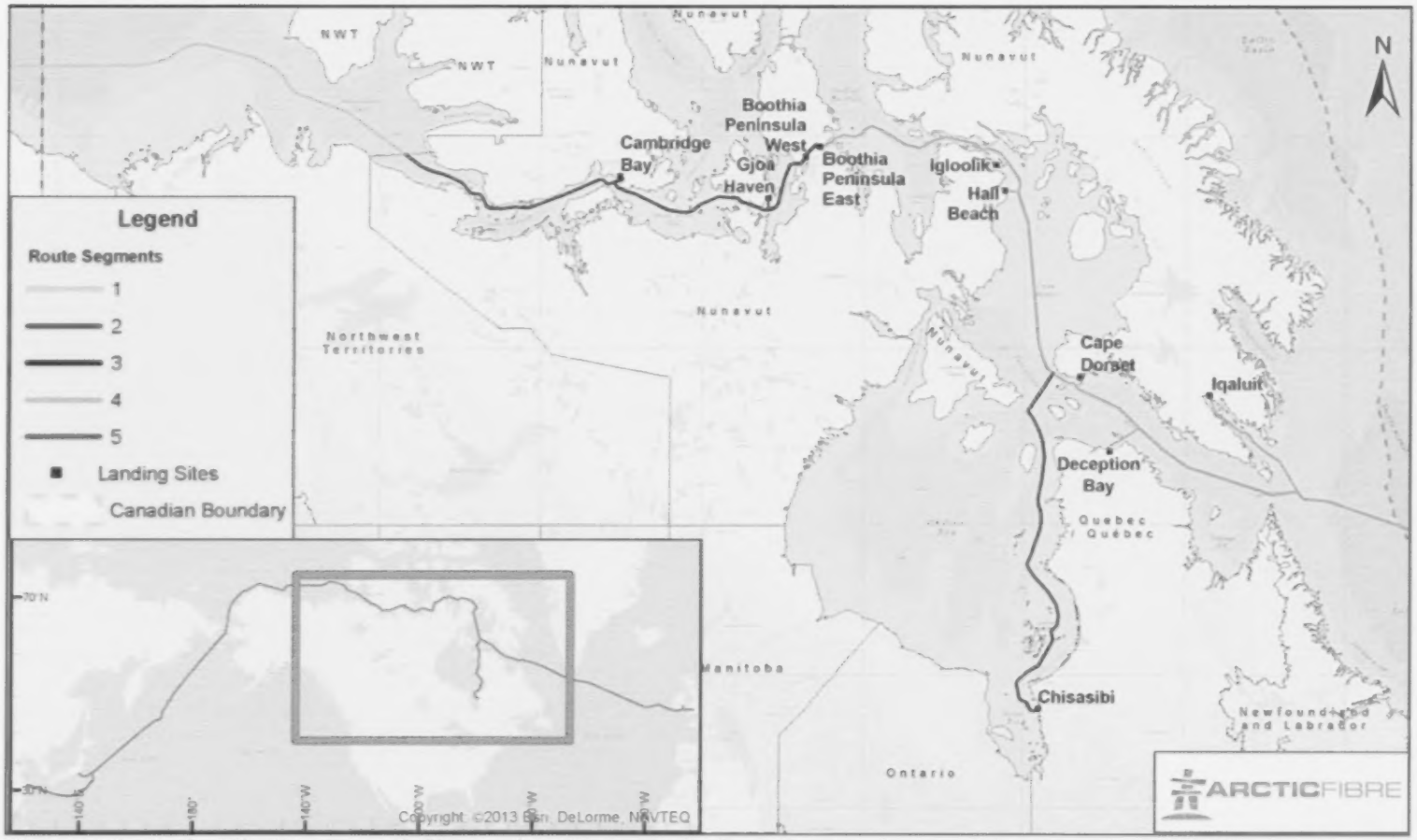


Figure 18. Arctic Fibre's proposed fibre optic telecommunications system, demonstrating the primary backbone of the network divided into five route segments. Phase 1 of the project involves installing a primary network cable from Japan to England, passing through the Northwest Passage of the Canadian Arctic and along the eastern coast of Hudson Bay through Chisasibi and eventually to Montreal and New York. Phase 2 would involve secondary networks branching off to several coastal communities in Newfoundland-Labrador, Québec, Nunavut, and the Northwest Territories (reproduced with permission from Arctic Fibre 2013).

CONCLUSION

Canada's North is a vast region that has seen little commercial or infrastructural development. The country harbours a large, diverse and relatively untapped mineral reserve in the Arctic which has gained significant international interest over the past decade. Further, the possibility that the Arctic Ocean seabed contains sizable deposits of hydrocarbons is leading to an increase in exploration and research efforts to prepare for industrial development. Economic incentive to develop the North will continue to grow as the demand for commodities increases globally and reserves in the south eventually decline. Furthermore, climate change may have a positive influence on future development in the North (Environment Canada and AANDC 2013).

The information gathered in this report suggests that Canada's northern regions will experience an unprecedented increase in industrial development over the next 10–20 years. Based on current plans and developmental timetables, more than 25 large-scale marine development projects, weighted by mining activities, can be expected to be operational by 2020 in Canada's North. These projects are widespread in all regions of the North, particularly in Labrador, Québec, Nunavut, and the Northwest Territories. Oil and gas projects would be mainly concentrated off Yukon and the Northwest Territories, while mining and infrastructure projects would be mainly concentrated in Nunavut, Québec, and Labrador. Marine regions in the Canadian Arctic that could consequently be exposed to a significant increase in vessel traffic include the Labrador Sea, Hudson Strait, Hudson Bay, Beaufort Sea, and Mackenzie Delta. If all mineral development projects planned between now and 2020 for Canada's North are combined, and if mines currently in production are included, up to 80 million tonnes of ore could be shipped through the Arctic marine regions. This represents up to 433 shipments per year, based on a vessel capacity of 180,000 dead-weight tonnes. It is difficult to predict the number of shipments that offshore oil and gas activities will require, mainly due to their early stages of development. However, the main oil and gas activity in the Canadian Arctic (particularly in the Labrador Sea, the Mackenzie Delta/Beaufort Sea region, and potentially Baffin Bay/Davis Strait) over the next five years is planned to be seismic surveying to evaluate potential hydrocarbon reserves.

The goal of this report was to provide a preliminary analysis and overview of areas in Canada's North which will likely undergo an increase in development activities and marine traffic. These areas are largely a reflection of where minerals and hydrocarbons are found in economically recoverable concentrations throughout the territory. Subsequent studies could include a comprehensive assessment of existing information on marine wildlife in the aim of identifying knowledge gaps for the areas in Canada's North where development activities will likely be concentrated. This represents an essential step for ensuring adequate baseline information and monitoring are established for short and longer term evaluation of environmental impacts of these development projects (Nowacek et al. 2013). Areas where baseline studies and monitoring could inform regulatory decisions related to oil and gas and mineral development may be identified using Fig. 5, which presents a general overview of planned development overlapped with Ecologically and Biologically Significant Areas in the Canadian Arctic.

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Appendix 1. Representative persons in provincial, territorial or federal governments of Canada, or review boards, who were contacted to validate the information related to resource development projects in this report. Persons or authorities listed who were not contacted, but may provide pertinent information related to their area of expertise, are indicated with an asterisk (*).

Region	Contact
Québec	**Manon Laliberté** Senior Analyst, Mining, Oil and Gas Fish Habitat Management Division Fisheries and Oceans Canada Maurice Lamontagne Institute 850 route de la Mer, P.O Box 1000, Mont-Joli, QC G5H 3Z4 Manon.Laliberte@dfo-mpo.gc.ca **François Hazel** Senior Analyst, Marine Environment and Navigation Fish Habitat Protection, Hydroelectricity, Navigation and Marine Environment Fisheries and Oceans Canada Maurice Lamontagne Institute 850 route de la Mer, P.O Box 1000, Mont-Joli, QC G5H 3Z4 Francois.Hazel@dfo-mpo.gc.ca **Mishal A. Naseer** (Nunavik)* Regional Planner Nunavik Marine Region Impact Review Board Kuujjuaq, QC mnaseer@nmrirb.ca
Ontario	**Brock Greenwell** Senior Statistical Analyst-Information and Marketing Ministry of Northern Development and Mines Government of Ontario 3 Sudbury St., Toronto, ON M6J 3W6 brock.greenwell@ontario.ca
Newfoundland & Labrador	**Lori Cook** Manager, Petroleum Geoscience Division Department of Natural Resources - Energy Branch Government of Newfoundland and Labrador 50 Elizabeth Ave., P.O. Box 8700, St. John's, NL A1B 4J6 LoriCook@gov.nl.ca

Appendix 1 cont'd. Representative persons in provincial, territorial or federal governments of Canada, or review boards, who were contacted to validate the information related to resource development projects in this report. Persons or authorities listed who were not contacted, but may provide pertinent information related to their area of expertise, are indicated with an asterisk (*).

Region	Contact
Newfoundland & Labrador	**Canada-Newfoundland and Labrador Offshore Petroleum Board** (C-NLOPB) 5th Floor, TD Place 140 Water Street, St. John's, NL, A1C 6H6 www.cnlopb.nl.ca
Manitoba	**Ernest Armitt** Director, Mines Administration 360-1395 Ellice Avenue Winnipeg, MB, R3G 3P2 Ernest.Armitt@gov.mb.ca
Nunavut	**Matthew Senkow** District Geologist - Mineral Resources Aboriginal Affairs and Northern Development Canada Nunavut Regional Office P.O. Box 100 Iqaluit, NU X0A 0H0 Matthew.Senkow@aandc.gc.ca **Nunavut Impact Review Board** PO Box 1360 Cambridge Bay, NU X0B 0C0 info@nirb.ca **CanNor, Nunavut Region*** 2nd Floor, Inuksugait Plaza, Building 1104B P.O. Box 40, Iqaluit, NU X0A 0H0 ecdevnunavut@cannor.gc.ca
Northwest Territories	**Lois Harwood** Marine Mammal Biologist Fisheries and Oceans Canada Suite 301 5204, 50th Ave., Yellowknife, NT X1A 1E2 Lois.Harwood@dfo-mpo.gc.ca **CanNor, Northwest Territories Region*** PO Box 1500, Yellowknife, NT X1A 2R3 EcDevNWT@cannor.gc.ca

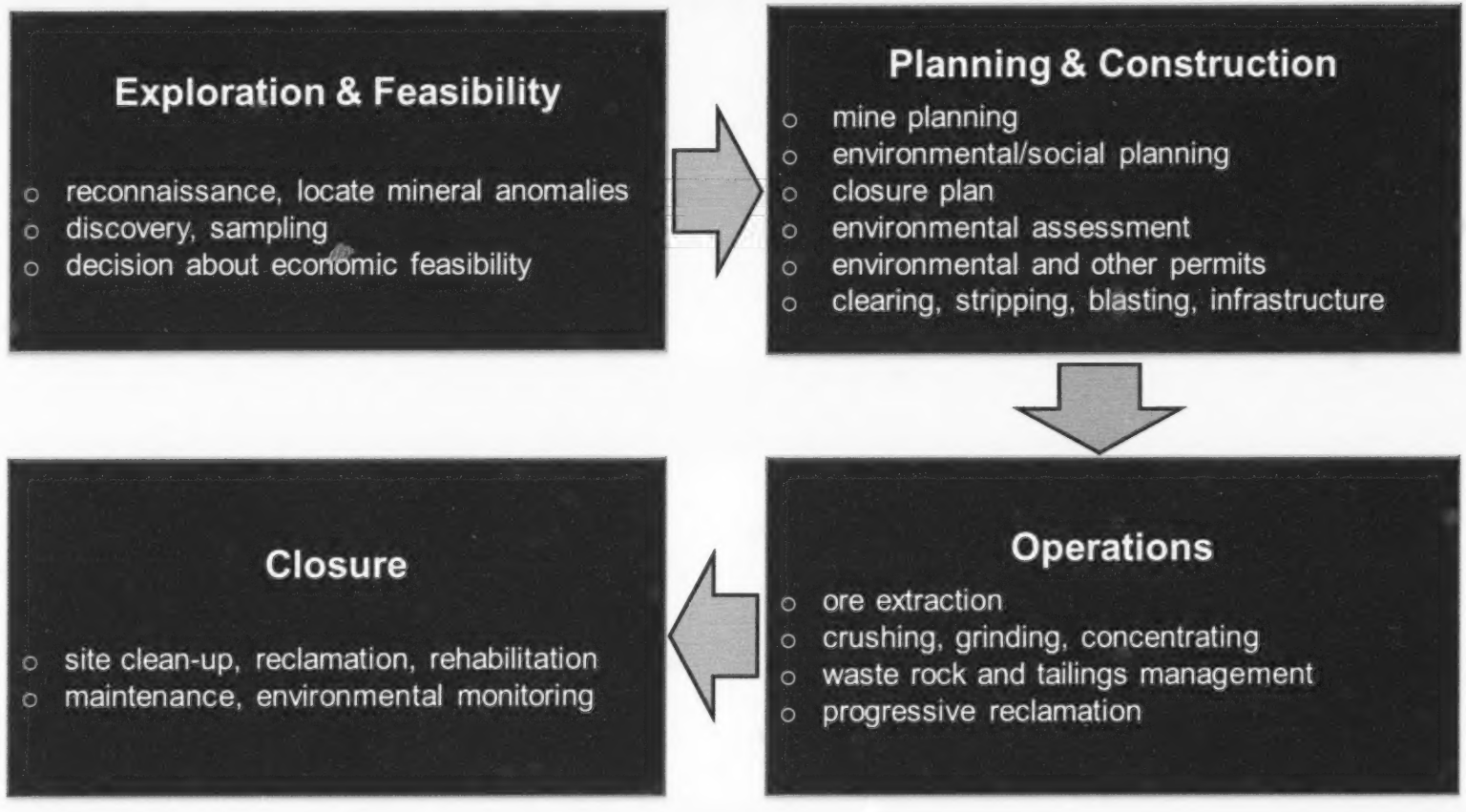
Appendix 1 cont'd. Representative persons in provincial, territorial or federal governments of Canada, or review boards, who were contacted to validate the information related to resource development projects in this report. Persons or authorities listed who were not contacted, but may provide pertinent information related to their area of expertise, are indicated with an asterisk (*).

Region	Contact
Mackenzie Delta-Beaufort Sea / Arctic Islands / Eastern Arctic	**George McCormick** Senior Environmental Advisor Northern Petroleum Directorate Northern Petroleum and Mineral Resources Branch Aboriginal Affairs and Northern Development Canada 25 Eddy St., Gatineau, QC K1A0H4 George.McCormick@aadnc-aandc.gc.ca **Darrell Christie*** Environmental Impact Screening Coordinator Environmental Impact Screening Committee Joint Secretariat – Inuvialuit Renewable Resource Committees 107 Mackenzie Road, Suite 204, PO Box 2120, Inuvik, NT X0E 0T0 eisc@jointsec.nt.ca
Yukon	**Bryony McIntyre** Manager, Mineral Planning and Development Yukon Government Administration Bldg. Box 2703 Whitehorse, YT Y1A 2C6 Bryony.McIntyre@gov.yk.ca **CanNor, Yukon Region*** Second Floor, Hougen Centre Suite 415c - 300 Main St Whitehorse, YT Y1A 2B5 Ytinfo@cannor.gc.ca
Canadian Arctic	**Manik Duggar*** Senior Project Manager Northern Projects Management Office Canadian Northern Economic Development Agency (CanNor) Nova Plaza, 2nd Floor, 5019-52nd Street Yellowknife, NT X1A 1T5 Tel: (867) 766-8470 Manik.Duggar@CanNor.gc.ca **National Energy Board** 444 Seventh Avenue SW Calgary, Alberta T2P 0X8 Tel: 1-800-899-1265 info@neb-one.gc.ca

Appendix 1 cont'd. Representative persons in provincial, territorial or federal governments of Canada, or review boards, who were contacted to validate the information related to resource development projects in this report. Persons or authorities listed who were not contacted, but may provide pertinent information related to their area of expertise, are indicated with an asterisk (*).

Region	Contact
Canadian Arctic	**Natural Resources Canada*** Oil and Gas Policy and Regulatory Affairs Division Petroleum Resources Branch Natural Resources Canada 580 Booth Street, 17th Floor, Ottawa, ON K1A 0E4 jforan@nrcan.gc.ca **Mineral & Petroleum Resources Directorate** Aboriginal Affairs and Northern Development Canada 10 Wellington, Gatineau, QC K1A 0H4 **Mineral Development Division** Tel: (867) 669-2571 mdd@inac.gc.ca **Petroleum Development Division** Tel: (867) 669-2469 pdd@inac.gc.ca
Arctic Shipping	**David R. Avey** Senior Marine Safety Inspector Marine Safety Transport Canada Tower C, Place de Ville, 330 Sparks St, Ottawa, ON, K1A 0N8 Tel: (613) 949-6554 david.avey@tc.gc.ca

Appendix 2. Overview of a mine life cycle, illustrated in four general phases (Environment Canada 2013).



Appendix 3. This Appendix contains information established by Transport Canada concerning the Shipping Safety Control Zones in the Canadian Arctic (Fig. A3), which are defined according to sea ice conditions throughout the year. The associated dates of entry into these Shipping Safety Control Zones depends on the type of vessel and are presented in Table A3.

Figure A3. Map of the Shipping Safety Control Zones in the Canadian Arctic. The marine area is divided into 16 geographical zones, in which the higher the zone number, the easier the ice conditions are for navigation (reproduced with permission from Transport Canada 2012).

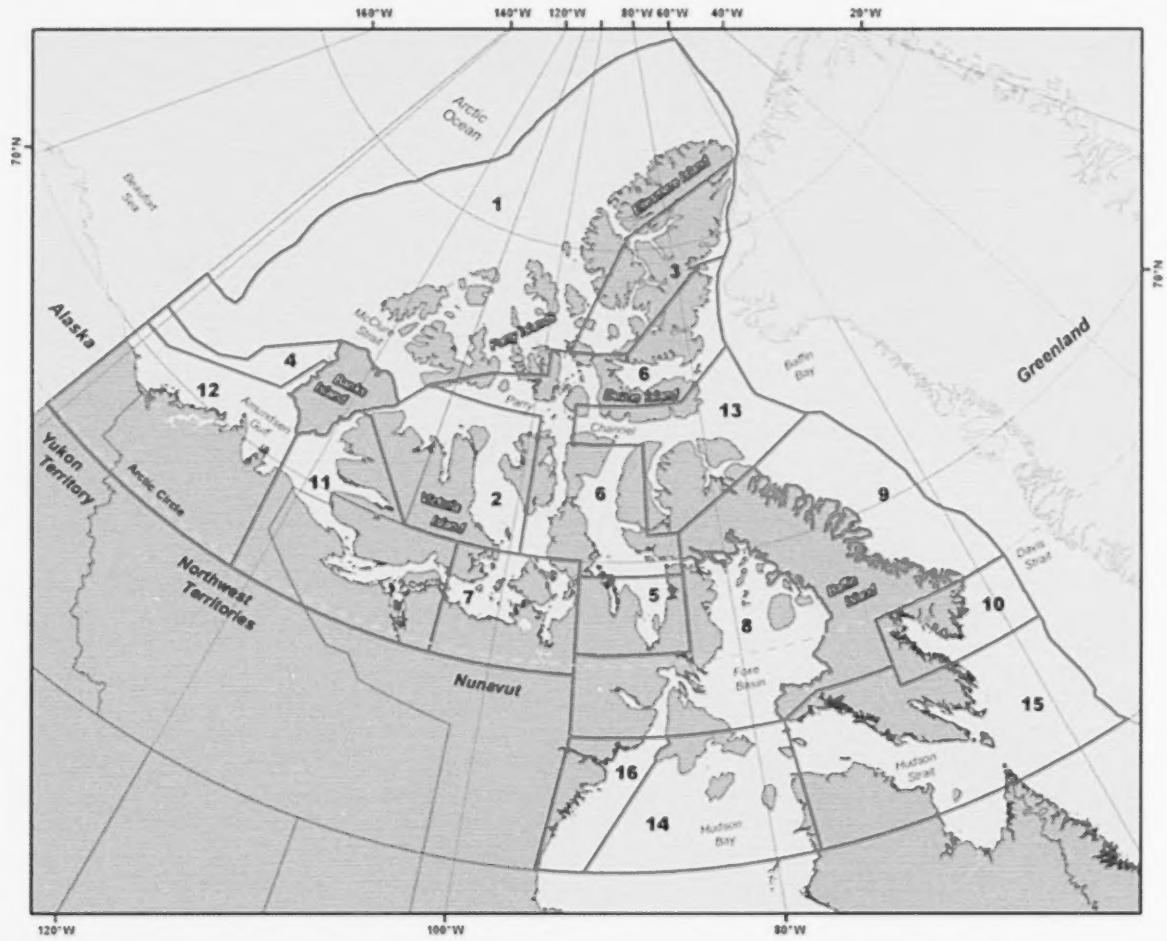


Table A3. Dates of entry by vessels of different categories into the Shipping Safety Control Zones in the Canadian Arctic (Appendix 3 Fig. 1). The period of open access to a zone is "based on historical data related to the probable ice conditions at that time of the year and on the hull strength classification of Arctic Class and Type". The class of a vessel (Category/ column 1) reflects its structural strength, displacement and power for breaking ice. Classes are designated as either "Arctic Class" vessels, which are built for more severe ice conditions, or "Type" vessels, which are designed for first-year ice. For example, Arctic Class 10 is a vessel designed for multi-year ice (no thickness limit), whereas Arctic Class 1 is built for thick (but less than 120cm) first-year ice. Type A vessels would be allowed to operate in ice thickness of 70–120cm, while Type E vessels could only operate in thin ice conditions (10–15cm) (reproduced with permission from Transport Canada 2012).

Category	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	Zone 11	Zone 12	Zone 13	Zone 14	Zone 15	Zone 16
Arctic Class 10	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*
Arctic Class 8	July 1 to Oct. 15	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*
Arctic Class 7	Aug. 1 to Sept. 30	Aug. 1 to Nov. 30	July 1 to Dec. 31	July 1 to Dec. 15	July 1 to Dec. 15	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*
Arctic Class 6	Aug. 15 to Sept. 15	Aug. 1 to Oct. 31	July 15 to Nov. 30	July 15 to Nov. 30	Aug. 1 to Oct. 15	July 15 to Feb. 28	July 1 to Mar. 31	July 1 to Mar. 31	*All Year*	*All Year*	July 1 to Mar. 31	*All Year*	*All Year*	*All Year*	*All Year*	*All Year*
Arctic Class 4	Aug. 15 to Sept. 15	Aug. 15 to Oct. 15	July 15 to Oct. 31	July 15 to Nov. 15	Aug. 15 to Sept. 30	July 20 to Dec. 31	July 15 to Jan. 15	July 15 to Jan. 15	July 10 to Mar. 31	July 10 to Feb. 28	July 5 to Jan. 15	June 1 to Jan. 31	June 1 to Feb. 15	June 15 to Feb. 15	June 15 to Mar. 15	June 1 to Feb. 15
Arctic Class 3	Aug. 20 to Sept. 15	Aug. 20 to Sept. 30	July 25 to Oct. 15	July 20 to Nov. 5	Aug. 20 to Sept. 25	Aug. 1 to Nov. 30	July 20 to Dec. 15	July 20 to Dec. 31	July 20 to Jan. 20	July 15 to Jan. 25	July 5 to Dec. 15	June 10 to Dec. 31	June 10 to Dec. 31	June 20 to Jan. 10	June 20 to Jan. 31	June 5 to Jan. 10
Arctic Class 2	*No Entry*	*No Entry*	Aug. 15 to Sept. 30	Aug. 1 to Oct. 31	*No Entry*	Aug. 15 to Nov. 20	Aug. 1 to Nov. 20	Aug. 1 to Nov. 30	Aug. 1 to Dec. 20	July 25 to Dec. 20	July 10 to Nov. 20	June 15 to Dec. 5	June 25 to Nov. 22	June 25 to Dec. 10	June 25 to Dec. 20	June 10 to Dec. 10
Arctic Class 1A	*No Entry*	*No Entry*	Aug. 20 to Sept. 15	Aug. 20 to Sept. 30	*No Entry*	Aug. 25 to Oct. 31	Aug. 10 to Nov. 5	Aug. 10 to Nov. 20	Aug. 10 to Dec. 10	Aug. 1 to Dec. 10	July 15 to Nov. 10	July 1 to Nov. 10	July 15 to Oct. 31	July 1 to Nov. 30	July 1 to Dec. 10	June 20 to Nov. 30
Arctic Class 1	*No Entry*	*No Entry*	*No Entry*	*No Entry*	*No Entry*	Aug. 25 to Sept. 30	Aug. 10 to Oct. 15	Aug. 10 to Oct. 31	Aug. 10 to Oct. 31	Aug. 1 to Oct. 31	July 15 to Oct. 20	July 1 to Oct. 31	July 15 to Oct. 15	July 1 to Nov. 30	July 1 to Nov. 30	June 20 to Nov. 15
Type A	*No Entry*	*No Entry*	Aug. 20 to Sept. 10	Aug. 20 to Sept. 20	*No Entry*	Aug. 15 to Oct. 15	Aug. 1 to Oct. 25	Aug. 1 to Nov. 10	Aug. 1 to Nov. 20	July 25 to Nov. 20	July 10 to Oct. 31	June 15 to Nov. 10	June 25 to Oct. 22	June 25 to Nov. 30	June 25 to Dec. 5	June 20 to Nov. 20
Type B	*No Entry*	*No Entry*	Aug. 20 to Sept. 5	Aug. 20 to Sept. 15	*No Entry*	Aug. 25 to Sept. 30	Aug. 10 to Oct. 15	Aug. 10 to Oct. 31	Aug. 10 to Oct. 31	Aug. 1 to Oct. 31	July 15 to Oct. 20	July 1 to Oct. 25	July 15 to Oct. 15	July 1 to Nov. 30	July 1 to Nov. 30	June 20 to Nov. 10
Type C	*No Entry*	*No Entry*	*No Entry*	*No Entry*	*No Entry*	Aug. 25 to Sept. 25	Aug. 10 to Oct. 10	Aug. 10 to Oct. 25	Aug. 10 to Oct. 25	Aug. 1 to Oct. 25	July 15 to Oct. 15	July 1 to Oct. 25	July 15 to Oct. 10	July 1 to Nov. 25	July 1 to Nov. 25	June 25 to Nov. 10
Type D	*No Entry*	*No Entry*	*No Entry*	*No Entry*	*No Entry*	*No Entry*	Aug. 10 to Oct. 5	Aug. 15 to Oct. 20	Aug. 15 to Oct. 20	Aug. 5 to Oct. 20	July 15 to Oct. 10	July 1 to Oct. 20	July 30 to Sept. 30	July 10 to Nov. 10	July 5 to Nov. 10	July 1 to Oct. 31
Type E	*No Entry*	*No Entry*	*No Entry*	*No Entry*	*No Entry*	*No Entry*	Aug. 10 to Sept. 30	Aug. 20 to Oct. 20	Aug. 20 to Oct. 15	Aug. 10 to Oct. 20	July 15 to Sept. 30	July 1 to Oct. 20	Aug. 15 to Sept. 20	July 20 to Oct. 31	July 20 to Nov. 5	July 1 to Oct. 31

Appendix 4. The following Appendix provides website references for mining and oil and gas research and operation developments described in this report. Table A4a provides references for Table 3 (p. 13); Table A4b provides references for Table 4 (p. 17); and Table A4c provides references for Table 5 (p. 19).

Table A4a. Mineral resource development projects and associated references. All websites accessed between 1 January and 30 March 2013.

Mine	References
Voisey's Bay (Labrador)	www.vbnc.com www.ceaa-acee.gc.ca/default.asp?lang=En&n=0a571a1a-1&xml=0a571a1a-84cd-496b-969c-7cf9cbca16ac&offset=11&toc=show www.vbnc.com/WinterShipping.asp
Churchill River Project (Labrador)	www.ironsands.ca www.expolabrador.com/presentations_2012/MacKenzie_NAIC.pdf www.petmin.co.za/ir/press/2011/21nov_2011.asp
Foxtrot Project (Labrador)	www.searchminerals.ca/i/pdf/factsheet/FACT-SHEET-Sep-2012.pdf www.searchminerals.ca/s/phs_district.asp; http://www.searchminerals.ca/i/pdf/ppt/SMY-Sep-2012.pdf; www.searchminerals.ca/i/pdf/reports/RPA-Foxtrot-July2012.pdf
Michelin Project (Labrador)	www.paladinenergy.com.au/default.aspx?MenuID=196
Raglan mine (Québec)	www.xstratanickelraglan.ca/EN/Pages/default.aspx
Nunavik Nickel (Québec)	www.goldbrookventures.com/media/Goldbrook%20NI%2043-101%20Nunavik%20Nickel%20Project_FINAL%20April%2014%202010_V.2.pdf www.ceaa.gc.ca/052/details-eng.cfm?pid=66172 www.nunatsiaqonline.ca/stories/article/65674fednav_canadian_royalties_ink_deal_for_nunavik_nickel_mine_icebreaker
Eldor Project (Québec)	www.commerceresources.com/i/pdf/2012-07-04_GG-PEA-Report.pdf www.commerceresources.com/i/pdf/presentation.pdf www.mric.jogmec.go.jp/kouenkai_index/2012/briefing_121109_5.pdf
Hopes Advance Bay (Québec)	www.oceanicironore.com/projects/technical-reports/ www.oceanicironore.com/projects/ungava-bay-iron-ore-deposits/; http://www.ceaa-acee.gc.ca/050/details-eng.cfm?evaluation=80008
Duncan Lake (Québec)	www.centuryiron.com/sites/default/files/duncan_lake_ni_43-101-r1.pdf www.centuryiron.com/content/duncan-lake-iron-ore-property www.augyvamining.com/i/pdf/corporatepresentation.pdf
Strange Lake (Québec)	www.questrareminerals.com/strangelakeproject.php www.questrareminerals.com/pdfs/Quest-Corporate-Presentation-March1to8.pdf/
Meadow-bank (Nunavut)	www.agnico-eagle.com/English/Our-Business/Operating-Mines/Meadowbank/Overview/default.aspx

Table A4a cont'd. Mineral resource development projects and associated references. All websites accessed between 1 January and 30 March 2013.

Mine	References
Meliadine (Nunavut)	www.agnico-eagle.com/English/Our-Business/GrowthProjects/Meliadine/Overview/default.aspx www.agnico-eagle.com/English/Investor-Centre/Presentations/default.aspx; http://npmo-bgpn.cannor.gc.ca/NPTracker/Project-Project-01.aspx?PID=25 http://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/11MN034-AEM%20MELIADINE/2-REVIEW/06-DRAFT%20EIS%20%26%20CONFORMITY%20REVIEW/02-DEIS%20SUBMISSION/VOLUME%208/130125-11MN034-Shipping%20Mgmt%20Plan-IT6E.pdf
Mary River (Nunavut)	www.baffinland.com/mary-river-project/?lang=en www.nunatsiaqonline.ca/stories/article/65674iqaluit_technical_review_puts_spotlight_on_nunavuts_mary_river_project/
Kiggavik (Nunavut)	www.kiggavik.ca/project-overview/; http://npmo-bgpn.cannor.gc.ca/NPTracker/Project-Project-01.aspx?PID=4
Izok Corridor (Nunavut)	www.mmg.com/en/Our-Operations/Development-projects/Izok-Corridor/Project-outline.aspx www.ftp.nirb.ca/01-SCREENINGS/COMPLETED%20SCREENINGS/2012/12MN043-MMG-%20Izok%20Corridor/01-APPLICATION/
Hackett River (Nunavut)	www.sabinagoldsilver.com/s/Hackett_River.asp www.infomine.com/index/pr/PB258356.PDF; http://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/08MN006-SABINA%20HACKETT%20RIVER/2-REVIEW/03-SCOPING%20%26%20GUIDELINES/SCOPING/CORRESPONDENCE/081113-08MN006-Potential%20Shipping%20Routes-IT4E.pdf
Back River (Nunavut)	www.sabinagoldsilver.com/s/BackRiverResources.asp www.sabinagoldsilver.com/i/pdf/BackRiver_PEA_Report_2CS031%20000_Sabina_JY_20120629.pdf; www.backriverproject.com/ http://ftp.nirb.ca/01-SCREENINGS/COMPLETED%20SCREENINGS/2012/12MN036-Sabina-Back%20River/01-APPLICATION/
Roche Bay (Nunavut)	www.advanced-exploration.com/projects/RocheBay/feasibility/index.html www.advanced-exploration.com/_files/file.php?fileid=filesrWfnJXdGl&filename=file_2013_Jan__Website_CorporatePresentation_final.pdf www.marketwire.com/press-release/advanced-explorations-signs-mou-with-logistec-stevedoring-inc-tsx-venture-axi-1757917.htm

Table A4b. Oil and gas exploration and development research projects and associated references. All websites accessed between 1 January and 30 March 2013.

Project name	Proponent	References
Geo-mapping for Energy	Natural Resources Canada and partners	www.nrcan.gc.ca/earth-sciences/about/current-program/geomapping/energy/8908
Beaufort Sea Geoscience Research Program	Geological Survey of Canada and partners	http://data.nwtresearch.com/Scientific/15174

Table A4c. Oil and gas exploration and development operations and associated references. All websites accessed between 1 January and 30 March 2013.

Project name	Proponent	References
North-Eastern Canada 2D Seismic Survey	TGS, PGS and MKI	www.neb-one.gc.ca/clf-nsi/rthnb/nrthffshr/dclrtnsgnfcntcmmrcldscvr/tgspgs2011nrthstrncnd/marnssmcsrvy-eng.pdf
Offshore Multi-Season Drilling Program on EL476 (Ajurak)	Imperial Oil Resources Ventures Ltd, ExxonMobil Canada Ltd	www.imperialoil.ca/Canada-English/Files/PIP_Beaufort_Sea_Explor_JV_with_Cover.pdf
Offshore Multi-Season Drilling Program on EL477 (Pokak)	Imperial Oil Resources Ventures Ltd, BP Exploration Operating Company Ltd	www.imperialoil.ca/Canada-English/Files/PIP_Beaufort_Sea_Explor_JV_with_Cover.pdf
Seismic survey program (EL484, EL485, EL488-EL493)	Franklin Petroleum Ltd	www.screeningcommittee.ca
Gas production on PL06	Inuvik Gas Ltd	www.inuvikgas.com/corporate.html

Table A4c cont'd. Oil and gas exploration and development operations and associated references. All websites accessed between 1 January and 30 March 2013.

Project name	Proponent	References
Labrador Shelf Seismic Project	Multi Klient Invest AS	www.cnlopb.nl.ca/pdfs/mkiseislab/mkieaupdate.pdf; www.cnlopb.nl.ca/pdfs/mkiseislab/screen_report.pdf
Labrador-SPAN 2D Seismic, Gravity and Magnetic Survey	GX Technology Canada Ltd	www.cnlopb.nl.ca/pdfs/gxtc/projdesc.pdf
Labrador Shelf Seismic Program on EL1109	Chevron Canada Ltd	www.cnlopb.nl.ca/pdfs/chevronseis/chevprojdesc.pdf; www.cnlopb.nl.ca/pdfs/chevronseis/chevseisfinalscreen.pdf
Labrador Shelf Seismic Program on EL1106-1109	Husky Oil Operations Ltd	www.cnlopb.nl.ca/pdfs/huskyseis/hs_sreport.pdf
Labrador Shelf Seismic Program on EL1107	Investcan Energy Corp	www.cnlopb.nl.ca/pdfs/investcan/inv_sr.pdf